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Information technology — Automatic identification and data capture techniques — Radio frequency identification device performance test methods

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British Standards

National foreword

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The British Standards which implement international publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

Summary of pages

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TECHNICAL REPORT

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Information technology — Automatic identification and data capture techniques — Radio frequency identification device performance test methods

Technologies de l'information — Techniques d'identification automatique et de capture des données — Méthodes d'essai de performance de dispositif d'identification par radiofréquence

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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 18046, which is a Technical Report of type 2, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

Introduction

RFID technology has broad applicability to the Automatic Identification and Data Capture (AIDC) industry in item management. As a wireless communication technique based on Radio Frequency technology the applications cover multiple levels of the industrial, commercial and retail supply chains. These may include:

- Freight containers
- Returnable Transport Items (RTI)
- Transport units
- Product packaging
- Product tagging

The performance characteristics of devices (tags and interrogation equipment) may vary drastically due to application factors as well as the particular RF air interface (frequency, modulation, protocol, etc.) being supported. Of key concern is the matching of the various performance characteristics to the user application. Additionally, in an open environment users of such technology demand multiple sources for these devices from technology providers. A key challenge is a method of evaluating the differences between various technology providers' products in a consistent and equitable manner.

This technical report provides a framework for meeting the above noted concern and challenges. To this end, a clear definition of performance as it relates to user application of RFID technology in the supply chain is provided. Based on such application-based definitions test methods are defined with attention to the test parameters that must be defined and controlled for a consistent evaluation of RFID devices.

It should be noted that the test methods defined in this document form the basic framework for performance evaluation and are not exhaustive. Many applications may require a slightly different set of test conditions to match the use of RFID to the user requirements. The test methods defined herein may be modified to accommodate the specifics of the application as specified by the user.

Of particular significance, these tests are defined for RFID devices having one antenna. It is common practice to have products with both single and multiple antennas to define an RFID transaction zone sufficient for the application. The defined methods can easily be extended from equipment with a single antenna to apply to equipment with multiple antennas, in order to evaluate performance under conditions more closely matching those of a particular application.

Information technology — Automatic identification and data capture techniques — Radio frequency identification device performance test methods

1 Scope

This Technical Report provides test method guidelines for performance characteristics of radio frequency identification (RFID) devices (tags and interrogation equipment) for item management, and specifies the general requirements and test requirements for tag and interrogator performance which are applicable to the selection of the devices for an application. It does not apply to testing in relation to regulatory or similar requirements.

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 18000-1:2004, *Information technology — Radio frequency identification for item management — Part 1: Reference architecture and definition of parameters to be standardized*

ISO/IEC 18000-2:2004, *Information technology — Radio frequency identification for item management — Part 2: Parameters for air interface communications below 135 kHz*

ISO/IEC 18000-3:2004, *Information technology — Radio frequency identification for item management — Part 3: Parameters for air interface communications at 13,56 MHz*

ISO/IEC 18000-4:2004, *Information technology — Radio frequency identification for item management — Part 4: Parameters for air interface communications at 2,45 GHz*

ISO/IEC 18000-6:2004, *Information technology — Radio frequency identification for item management — Part 6: Parameters for air interface communications at 860 MHz to 960 MHz*

ISO/IEC 18000-7:2004, *Information technology — Radio frequency identification for item management — Part 7: Parameters for active air interface communications at 433 MHz*

ISO/IEC 19762-3, *Information technology — Automatic identification and data capture techniques — Harmonized vocabulary — Part 3: Radio frequency identification (RFID)*[1)]

1) To be published.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
identification range
range at which an RFID system shall reliably identify desired tags under a variety of conditions

[ISO/IEC 19762-3]

3.2
identification rate
rate at which an RFID system shall reliably identify desired tags under a variety of conditions

[ISO/IEC 19762-3]

3.3
read range
range at which an RFID system may reliably read from desired tags under a variety of conditions

[ISO/IEC 19762-3]

3.4
read rate
rate at which an RFID system shall reliably read desired tags under a variety of conditions

[ISO/IEC 19762-3]

3.5
write range
range at which an RFID system may reliably write to desired tags under a variety of conditions

[ISO/IEC 19762-3]

3.6
write rate
rate at which an RFID system shall reliably write desired tags under a variety of conditions

[ISO/IEC 19762-3]

4 Symbols and abbreviated terms

EUT – Equipment under test

5 General concepts

5.1 Identification

An RFID system for item management must perform a sequence of communication processes within an “open” RF environment to transact the desired data with one or more tags in a potentially large tag population. This process begins with activation and segregation of the desired tags (small population) within the “open” larger population. This process concludes with the establishment of a communication link between the RFID interrogator and the tag allowing transaction (reading and/or writing) of application data. This initial process is described as “Identification”. Identification specifically refers to the process of tag segregation and isolation. This will result in a uniquely addressable means to communicate with a tag (tag ID). Application data has not been accessed.

5.2 Range

An RFID system for item management requires the segregation and transaction of information remotely (i.e. non-line-of-sight). The physical separation between the interrogator and the tag is commonly referred to as range. Range specifically refers to the distance (minimum and maximum) between interrogator antenna and tag(s). For multiple tags, the range will be measured to the geometric centroid of the tag population. Tag density (tags per unit volume) will be specified.

5.3 Rate

An RFID system for item management may (and typically will) encounter multiple tags within a data acquisition session. As many applications require multiple tags to be processed within a fixed amount of time, a performance parameter dealing with “rate” is appropriate. Rate specifically refers to the quantity of tags per unit time. This includes impulse and steady state. Tag population will be both static and dynamic. Tag density (tags per unit volume) will be specified

5.4 Read

RFID tags contain data. This data represents information about the item associated with the tag whether directly (item attendant) or indirectly (license plate). One of the significant performance characteristics of RFID relates to the ability of retrieving this “item data” in support of various business process requirements. This retrieval process is commonly referred to as “reading” and is separate from the previously described process of “identification”.

Reading tag information assumes that a communication link has been established between the RFID interrogator and the tag. As such the collision arbitration (sometimes referred to as anti-collision) process is not involved. Reading of tag data is a “directed” data transaction with the activated and segregated tag. Reading specifically refers to the process of tag transaction to retrieve information from identified tag population. This process will include both single byte and multiple byte transactions.

5.5 Write

As noted previously, RFID tags contain data. This data represents information about the item associated with the tag whether directly (item attendant) or indirectly (license plate). This information may at times be added and/or modified through the RFID air interface. Should such a capability be available as part of an RFID system, a significant performance characteristic would be the ability of transferring this “item data” from the interrogator into the tag. This process is commonly referred to as “writing” and is the inverse of the previously described process of “reading”.

Writing tag information assumes that a communication link has been established between the RFID interrogator and the tag. As such the collision arbitration (sometimes referred to as anti-collision) process is not involved. Writing of tag data is a “directed” data transaction with the activated and segregated tag. Writing specifically refers to the process of tag transaction to write information into identified tag population. This process will include both single byte and multiple byte transactions. Write with verification will be available.

5.6 Reliable

RFID systems may require extensive dialog between the interrogator and the tag to fully complete the desired transaction with the tag population. It is not uncommon to have dialog errors during wireless communication. Various mechanisms (e.g. checksum, CRC, retransmission, etc.) may be used to ensure the integrity of the transactions. A reliable transaction specifically refers to the assurance that a tag and/or tag population will be identified accurately based on statistical likelihood and a defined confidence level.

5.7 Conditions

RFID systems must perform the required transactions (i.e. identification, reading, or writing) under a variety of environmental and application conditions. Such conditions specifically refer to the following:

- Environmental (temperature, humidity, RF spectrum, physical)
- Tag population (quantity, density, motion, orientation, mounting material(s))

6 Requirements

6.1 Introduction

The following section defines the requirements by which RFID systems will be evaluated to describe their performance parameters. It should be noted that there are a number of system and environmental factors which influence and bound the performance characteristics of an RFID system. As referenced, the RFID performance parameters relate to “system” characteristics and thus require both an interrogator as well as tags for their measurement.

6.2 General

An RFID system information transaction volume (range) and/or speed (rate) are defined by many factors. The relevant factors and their form will vary depending on the RFID technology (i.e. inductive or propagative) involved. The following represents some of the relevant factors for the respective system component and environment:

- Interrogator
  - Frequency
  - Power or field strength
  - Antenna directivity (i.e. gain) and polarization or Q factor
  - Receiver sensitivity
  - Modulation characteristic
- Tag
  - Activation sensitivity (i.e. minimum field strength or power density)
  - Antenna directivity (i.e. gain) and polarization or Q factor
  - Modulation characteristic
- Tag application surface
  - Paper
  - Wood
  - Glass
  - Plastic
  - Metal

- Application environment
  - RF reflective and absorptive surfaces
  - Moisture (e.g. humidity, condensation, ice, etc.)
  - Chemicals
  - Radio Frequency (RF)
  - Electrical

6.3 Test conditions

Given the realities and complexities of such influencing factors, the following defined test methods are constrained to test environments and parameter variations which will allow for a consistent RFID performance characteristic to be measured. Such a measured characteristic may be used for the selection of devices for an application. The general test conditions for short range systems (i.e., under 10 meters) are defined in Table 1 — Short range test conditions below:

Table 1 — Short range test conditions

Condition	Range	Comment
Distance	0 – 10 metres	3-D (x, y, z)
Tag population	1, 10, 20, 50,100	
Tag geometry	Linear, array, volume	
Tag orientation	0, 30, 60, 90 deg, random	3-D (ψ, θ, ϕ)
Tag volume	0.016, 0.125, 1 m^3	
Tag speed	0, 1, 2, 5, 10 m/s	
Tag mounting material	Paper, wood, glass, plastic, metal	See list below
RF environment	Benign, moderate, congested	WLAN, machinery, etc.
Data transaction	1, 8, 16, 32 bytes	Read and write
Interrogator antenna height	0.5, 1, 2, 3 metres	Distance above ground plane (propagative)

The general test conditions for long range systems (i.e., over 10 metres), such as those systems covered by IEC/ISO 18000-7, are defined in Table 2 — Long range test conditions below:

Table 2 — Long range test conditions

Condition	Range	Comment
Distance	10 – 100 metres	3-D (x, y, z)
Tag population	1, 10, 20, 50,100	
Tag geometry	Linear, array, volume	
Tag orientation	0, 30, 60, 90 deg, random	3-D (ψ, θ, ϕ)
Tag volume	0.016, 0.125, 1 m^3	
Tag speed	0, 1, 2, 5, 10 m/s	
Tag mounting material	Paper, wood, glass, plastic, metal	See list below
RF environment	Benign, moderate, congested	WLAN, machinery, etc.
Data transaction	1, 8, 16, 32 bytes	Read and write
Interrogator antenna height	0.5, 1, 2, 3 metres	Distance above ground plane (propagative)

These test conditions may be modified or extended to represent specific user application requirements. The test methods defined in this document may be performed with test conditions tailored to the specific application to best represent performance of RFID devices in such usage.

Tag mounting material – The list below is a representative list of materials for mounting tag(s) for evaluation. As materials will vary based on supply, such mounting structures shall record the source and physical characteristics (i.e. thickness, finish. size, etc.). Mounting structures for tag(s) shall not place metallic fasteners within 10 cm of tag(s).

- Corrugated paper
- Windshield glass
- Particle board
- Plywood
- Plexiglas
- Polypropylene
- Polycarbonate
- Aluminium
- Steel

The test condition shall utilize a controlled RF environment (i.e. anechoic chamber) when feasible. Use of Open Air Test Sites (OATS) is permissible to accommodate devices where distance and/or movement preclude the use of available anechoic chambers. Annex A defines test sites and general arrangements for measurements involving the use of radiated fields. Annex B defines test extensions and deviations from the base test methods peculiar to long range (i.e. greater than 10 metres) RFID systems.

6.4 Test parameters

6.4.1 Introduction

The defined test conditions include a variety of test parameters that provide a range of conditions for device evaluation. While these parameters shall be used as defined in Table 1 above, these parameters may be varied beyond the defaults listed to accommodate the device evaluation with respect to application requirements. These parameters are described in this section.

6.4.2 Distance

There are four measurable distance elements comprising the range parameter. These are:

- Minimum distance (z axis) – the minimum distance (metres) between the center of interrogator antenna and the centroid of the tag population under test. In the case where there are separate transmit and receive antennae, the maximum of the distances of the two shall be recorded. The z axis is defined to be the vector perpendicular to the plane of the antenna pointing outward toward the peak of the radiated field. This axis shall be oriented parallel to the ground plane for test purposes.

- Maximum distance (z axis) – the maximum distance (metres) between the center of the interrogator antenna and the centroid of the tag population under test. In the case where there are separate transmit and receive antennae, the minimum of the distances of the two shall be recorded. The z axis is defined to be the vector perpendicular to the plane of the antenna pointing outward toward the peak of the radiated field. This axis shall be oriented parallel to the ground plane for test purposes.

- Horizontal distance (x axis) – the maximum distance (metres) across the communication zone for the centroid of the tag population under test. The x axis is defined to be the horizontal vector perpendicular to the z axis and parallel to the ground plane.

- Vertical distance (y axis) – the maximum distance (metres) through the communication zone for the centroid of the tag population under test. The y axis is defined to be the vertical vector perpendicular to the z axis and perpendicular to the ground plane.

Figures 1 and 2 depict the general arrangement and relationship of the four distance elements of the range parameter. Note that the inner shaded region represents the measured effective communication zone from which the desired measurable performance parameter (i.e. range) is calculated. The outer shaded region represents the physical volume that a tag population may move through for the measured communication zone (i.e. inner region).

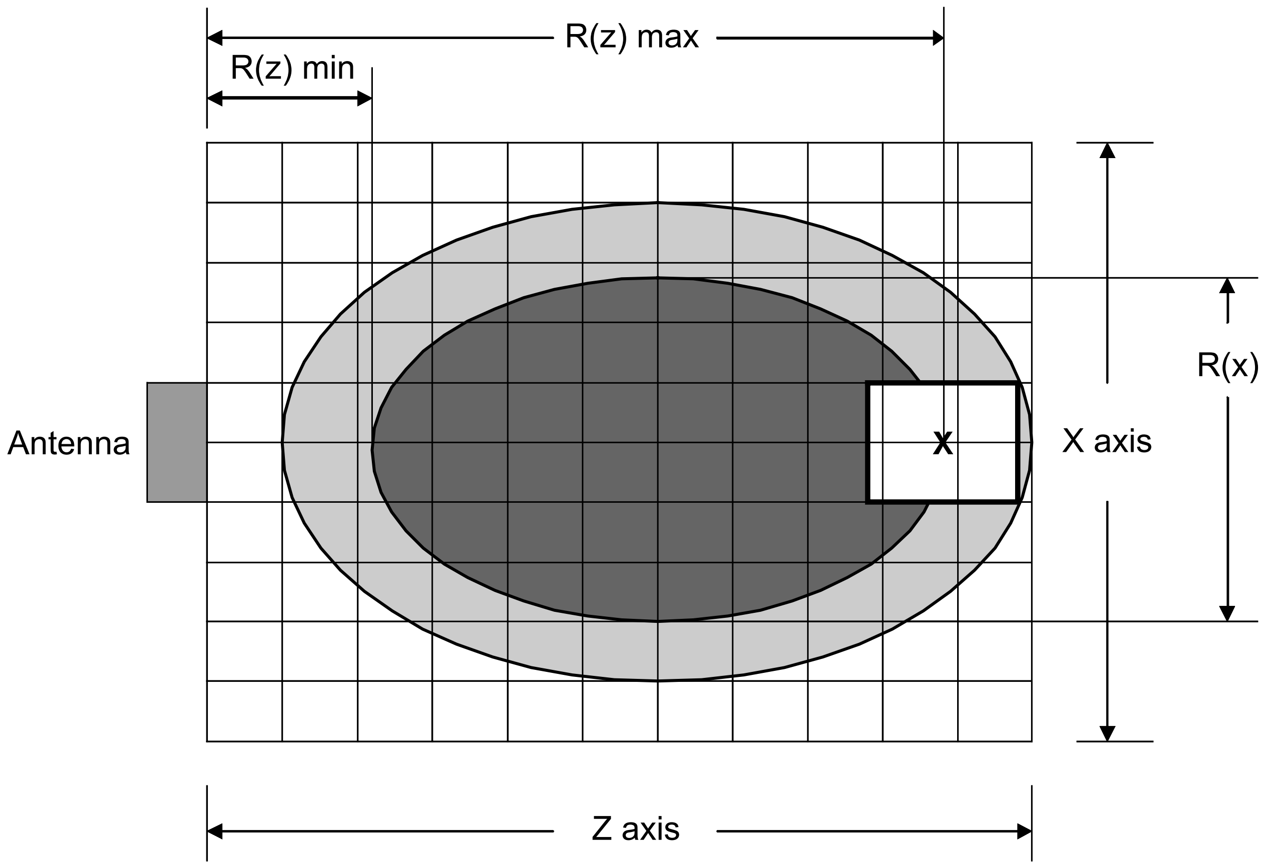


Figure 1 — Top down view of communication zone

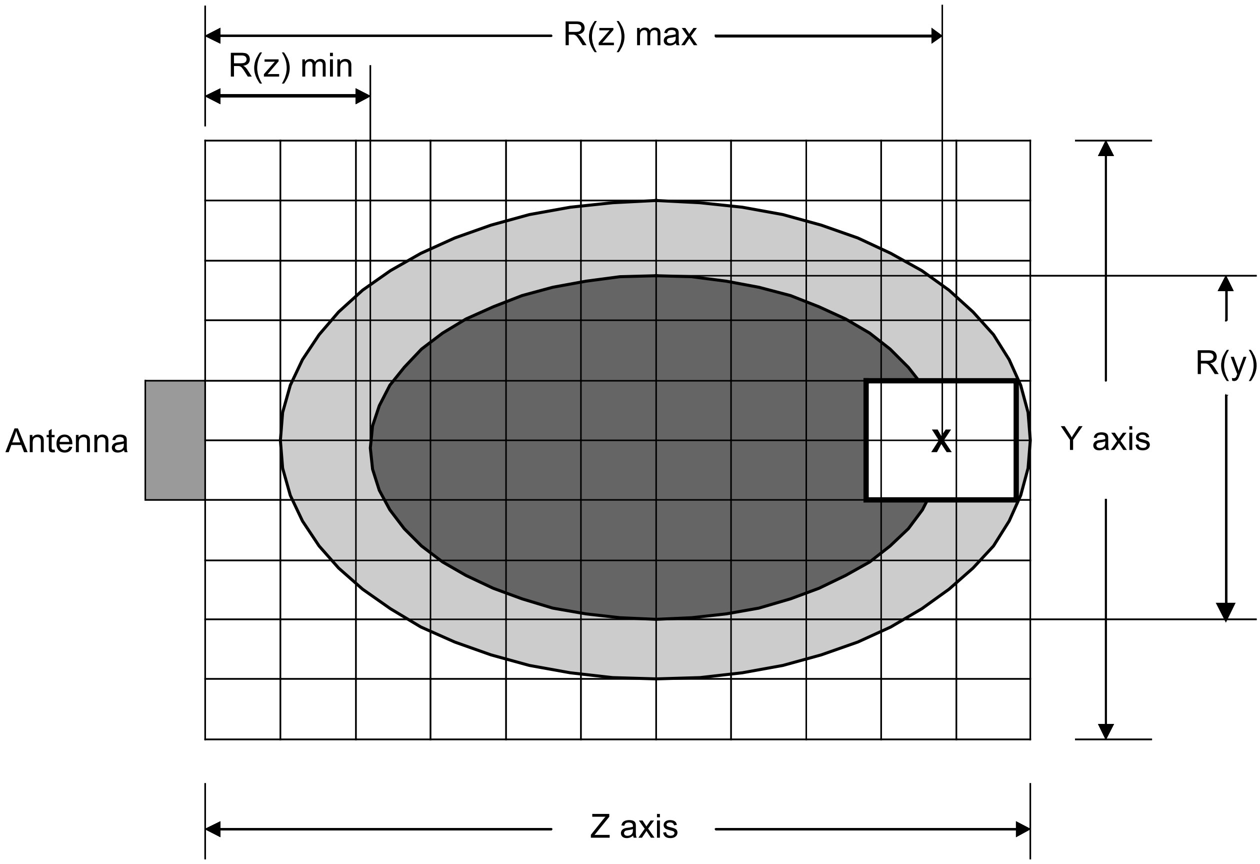


Figure 2 — Side view of communication zone

6.4.3 Tag population

The tag population shall consist of a group of tags arranged according to the defined geometry of test. The reference point for range measurements shall be the geometric centroid of the specified geometry.

6.4.4 Tag geometry

The geometric arrangement of the tags in a population under test may be linear (1D), array (2D), or volume (3D). The spacing of the tags within the defined geometry shall be uniform. Tag spacing shall be measured as the minimum distance between the geometric centroid of each tag. The diagrams below represent the three basic classes of tag geometry.

Figure 3 — Linear tag array

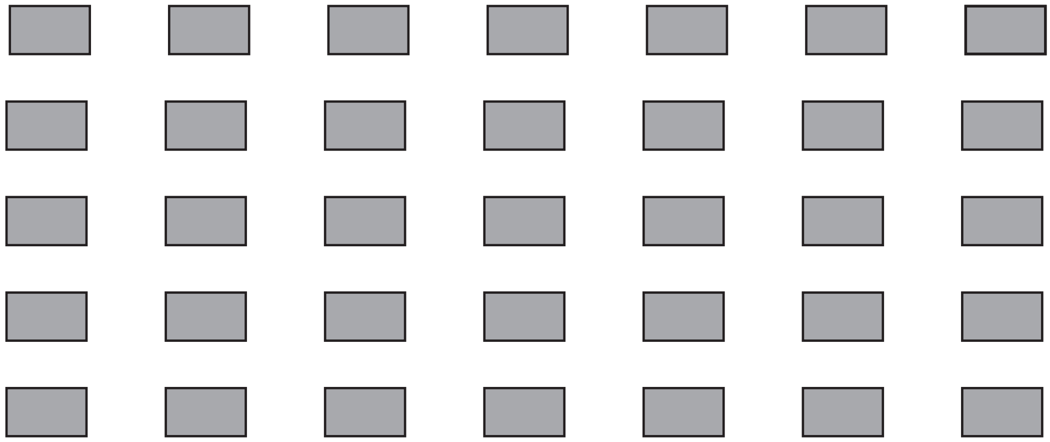


Figure 4 — 2D tag array

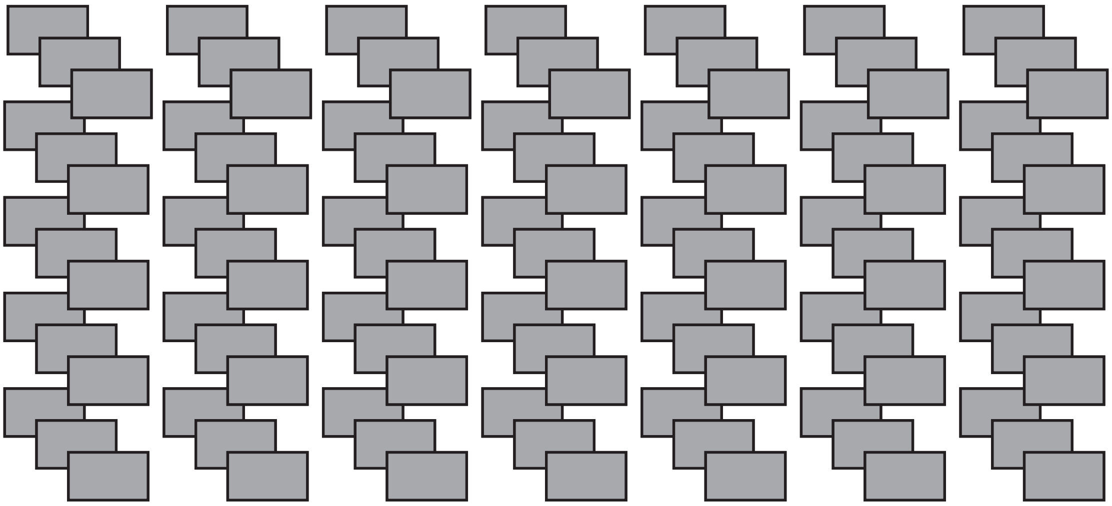


Figure 5 — 3D tag volume

6.4.5 Tag orientation

Tags within a population may have specified orientation (polarization) relative to the interrogator antenna. This orientation shall be defined relative to the z axis for the reference interrogator antenna. Orientation variation shall include angular rotations in three dimensions (ψ, θ, and ϕ). A "right-hand" orthogonal coordinate system shall be used to reference tag orientation. Random tag orientation may use RF transparent structural elements to facilitate uniform tag separation (e.g. density) within the tag volume. Polystyrene spheres are an example where tags may be placed within the structure individually. These "encased" tags may then be contained in an appropriate tag volume for evaluation.

Random tag orientation populations shall be "randomised" (i.e. redistributed) between test samples to ensure effective assessment of random sampling of a tag population with random orientation as it would interact with the communication zone.

6.4.6 Tag volume

Tag volume is defined for tag populations described as having "volume" geometry. For such tag population arrangements the volume shall be cubic (having equal dimensions in all three dimensions) bounding the tag population. The tag population shall be uniformly distributed within this bounding geometry. Structural material for establishing the bounding volume shall be transparent to the RF frequency of the interrogator and its nature shall be recorded as reference data.

6.4.7 Tag speed

Tag populations may be specified to be in motion relative to the interrogator antenna. Under such definition, moving either the interrogator or the tag population is allowed to provide flexibility for test environmental constraints. The movement of the tag population relative to the interrogator antenna shall be by a conveyance that minimizes the perturbation of the RF environment. This method of movement shall be recorded as reference data.

Application specific conveyances and transport mechanisms (i.e. conveyors, forklifts, etc.) may be used as specified for movement of a tag population beyond the default (minimised RF perturbation) method. Such evaluations would be application specific and the manner of conveyance shall be recorded as part of the reference data.

6.4.8 Tag mounting material

Tag populations may be specified to be mounted on a structural material for evaluation. Such material shall be flat and extend at least 15 cm beyond the outer boundary of the tag population. Tag population attachment shall be by means which minimize RF perturbation to the population under test. The tag population attachment method and material shall be recorded as reference data.

6.4.9 RF environment

The RF environment shall be documented as part of the collected test data. Such documentation relates to the conditions of test (i.e. anechoic chamber, Open Air Test Sites, etc.)

6.4.10 Data transaction

Reading and writing of information to tags represent the core element of data transactions. Read and Write performance parameters shall be evaluated with various amounts of data as depicted in Table 1. When multiple tags are being evaluated (i.e. tag populations greater than one), the same amount of data shall be transacted with each tag in the population. The data transferred during such transactions shall be varied to ensure the transaction performance is not influenced by the data content. When multiple tags are being evaluated, the data content shall be varied among the tags in the population to ensure the transaction performance is not influenced by the data content. Positive verification that accurate data transfer has taken place shall be performed (i.e. Read after Write) to ensure successful data transactions.

Data quantity and content may be specified to correspond to a specific application requirement for which the device is being evaluated. Data transaction definition shall be recorded as reference data.

7 Sampling

Rectilinear sampling shall be used as the basis for test. Rectilinear sampling means that the tag population is translated either perpendicular or parallel to the z-axis.

8 Test methods

8.1 Identification range

8.1.1 Individual tag

8.1.1.1 Purpose

This test shall evaluate the Identification Range of an RFID system (tag and interrogator). The range parameter shall consist of four computed measured values representing the geometric extent of the identification zone (volume) as described in clause 6.4.2 using a single tag. These measured values shall be:

- R(x) extent
- R(y) extent
- R(z) min
- R(z) max

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.1.1.2 Test procedure

The tag shall be moved (relative to the interrogator) in a geometric sampling volume stopping at each sample point. The sample volume shall be of sufficient size to fully encompass the interrogation volume. The sampling volume shall have a sampling resolution of 10 cm or less.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated at each sample point. Successful identifications shall be recorded. A successful identification shall be defined as the proper unique communication being established between the interrogator and the tag as defined in the RFID air interface protocol. All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

The test shall be repeated (as required) for a moving tag. For a moving tag the initiation of the activation signal shall be set to correspond to the sample points. Successful identifications shall be recorded.

8.1.1.3 Computation of results

The set of measurable data collected shall be computed to indicate identification volume described by the defined measured values above. The Identification Range shall be evaluated based on a 100% success criterion. If the identification zone contains regions (voids) where less than a 100% success identification criterion was measured, the quantity and size of these regions shall be recorded.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported Identification range parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.1.2 Multiple tags

8.1.2.1 Purpose

This test shall evaluate the Identification Range of an RFID system (tag and interrogator). The range parameter shall consist of four computed measured values representing the geometric extent of the identification zone (volume) as described in clause 6.4.2 using multiple tags. These measured values shall be:

- R(x) extent
- R(y) extent
- R(z) min
- R(z) max

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.1.2.2 Test procedure

The tag population (i.e. linear, 2D, and/or 3D) shall be moved (relative to the interrogator) in a geometric sampling volume stopping at each sample point. The sample volume shall be of sufficient size to encompass the interrogation volume fully. The sampling volume shall have a sampling resolution of 10 cm or smaller.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated at each sample point. Successful identifications shall be recorded. A successful identification shall be defined as the proper unique communication being established between the interrogator and the all tags as defined in the RFID air interface protocol. All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

The test shall be repeated (as required) for a moving tag population. For a moving tag population the initiation of the activation signal shall be set to correspond to the sample points. Successful identifications shall be recorded.

8.1.2.3 Computation of results

The set of measurable data collected shall be computed to indicate identification volume described by the defined measured values above. The Identification Range shall be evaluated based on a 100 % success criterion. If the identification zone contains regions (voids) where less than a 100% success identification criterion was measured, the quantity and size of these regions shall be recorded.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported Identification range parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.2 Identification rate

8.2.1 Individual tag

8.2.1.1 Purpose

This test shall evaluate the Identification Rate of an RFID system (tag and interrogator). The rate parameter shall consist of a computed measurable representing the tag segregation (anti-collision) performance of the system as described in clause 3.2 using a single tag. This measurable shall be stated in terms of "tags per second".

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.2.1.2 Test procedure

The tag shall be placed in a responsive part of the identification zone as established by the Identification Range test above. Multiple sample points within the volume shall be used. A minimum of 10 sample points shall be used.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated. The time from initiation of the activation signal to the completion of the identification process shall be recorded. The completion of the identification process shall include the time required to report the identification to application source. The application source may be a human operator, a secured buffer, or a "host" computer where application decisions are handled.

All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

The test shall be repeated (as required) for a moving tag. For a moving tag the initiation of the activation signal shall be set to correspond to the sample points. Successful identifications shall be recorded.

8.2.1.3 Computation of results

The set of measurable data collected shall be computed to indicate identification rate described by the defined measurable above. The Identification Rate shall be evaluated and reported as the average (arithmetic mean) of the measured values.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported Identification rate parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.2.2 Multiple tags

8.2.2.1 Purpose

This test shall evaluate the Identification Rate of an RFID system (tag and interrogator). The rate parameter shall consist of a computed measurable representing the tag segregation (anti-collision) performance of the system as described in clause 3.2 using multiple tags. This measurable shall be in terms of "tags per second".

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.2.2.2 Test procedure

The tag population (i.e. linear 2D, and/or 3D) shall be placed in responsive part of the identification zone as established by the Identification Range test above. Multiple sample points within the volume shall be used. A minimum of 10 sample points shall be used.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated. The time from initiation of the activation signal to the completion of the identification process shall be recorded. The completion of the identification process shall include the time required to report the identification of all tags to application source. The application source may be a human operator, a secured buffer, or a "host" computer where application decisions are handled.

All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

The test shall be repeated (as required) for a moving tag population. For a moving tag population the initiation of the activation signal shall be set to correspond to the sample points. Successful identifications shall be recorded.

8.2.2.3 Computation of results

The set of measurable data collected shall be computed to indicate identification rate described by the defined measurable above. The Identification Rate shall be evaluated and reported as the average (arithmetic mean) of the measured values.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported Identification rate parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.3 Read range

8.3.1 Individual tag

8.3.1.1 Purpose

This test shall evaluate the Read Range of an RFID system (tag and interrogator). The range parameter shall consist of six computed measured values representing the geometric extent of the read zone (volume) as described in clause 6.4.2 using a single tag. These measured values shall be:

- R(x) extent
- R(y) extent
- R(z) min
- R(z) max

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.3.1.2 Test procedure

The tag shall be moved (relative to the interrogator) in a geometric sampling volume stopping at each sample point. The sample volume shall be of sufficient size to fully encompass the interrogation volume. The sampling volume shall have a sampling resolution of 10 cm or smaller.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated at each sample point. A successful identification shall be defined as the proper unique communication being established between the interrogator and the tag as defined in the RFID air interface protocol. All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

Following successful identification data shall be "read" from the segregated tag. The amount of information shall be defined by the specified test conditions. The sample point is complete upon the successful retrieval of the tag data. Successful reads shall be recorded.

The test shall be repeated (as required) for a moving tag. For a moving tag the initiation of the activation signal shall be set to correspond to the sample points. Successful reads shall be recorded.

8.3.1.3 Computation of results

The set of measurable data collected shall be computed to indicate identification volume described by the defined measured values above. The Read Range shall be evaluated based on a 100% success criterion. If the identification zone contains regions (voids) where less than a 100% success identification criterion was measured, the quantity and size of these regions shall be recorded.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported read range parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.3.2 Multiple tags

8.3.2.1 Purpose

This test shall evaluate the Read Range of an RFID system (tag and interrogator). The range parameter shall consist of six computed measured values representing the geometric extent of the read zone (volume) as described in clause 6.4.2 using multiple tags. These measured values shall be:

- R(x) extent
- R(y) extent
- R(z) min
- R(z) max

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.3.2.2 Test procedure

The tag population (i.e. linear 2D, and/or 3D) shall be moved (relative to the interrogator) in a geometric sampling volume stopping at each sample point. The sample volume shall be of sufficient size to fully encompass the interrogation volume. The sampling volume shall have a sampling resolution of 10 cm or smaller.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated at each sample point. A successful identification shall be defined as the proper unique communication being established between the interrogator and the all tags as defined in the RFID air interface protocol. All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

Following successful identification data shall be "read" from the segregated tag. The amount of information shall be defined by the specified test conditions. The sample point is complete upon the successful retrieval of the tag population data. Successful reads shall be recorded.

The test shall be repeated (as required) for a moving tag population. For a moving tag population the initiation of the activation signal shall be set to correspond to the sample points. Successful reads shall be recorded.

8.3.2.3 Computation of results

The set of measurable data collected shall be computed to indicate identification volume described by the defined measured values above. The Identification Range shall be evaluated based on a 100% success criterion. If the identification zone contains regions (voids) where less than a 100% success identification criterion was measured, the quantity and size of these regions shall be recorded.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported read range parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.4 Read rate

8.4.1 Individual tag

8.4.1.1 Purpose

This test shall evaluate the Read Rate of an RFID system (tag and interrogator). The rate parameter shall consist of a computed measurable representing the tag reading performance of the system as described in clause 0 using a single tag. This measurable shall be in terms of "tags per second".

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.4.1.2 Test procedure

The tag shall be placed in responsive part of the read zone as established by the Read Range test above. Multiple sample points within the volume shall be used. A minimum of 10 sample points shall be used.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated. The time from initiation of the activation signal to the completion of the read process (e.g. successfully retrieve all requested tag data) shall be recorded. The completion of the read process shall include the time required to report all requested tag data to application source. The application source may be a human operator, a secured buffer, or a "host" computer where application decisions are handled.

All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

The test shall be repeated (as required) for a moving tag. For a moving tag the initiation of the activation signal shall be set to correspond to the sample points. Successful reads shall be recorded.

8.4.1.3 Computation of results

The set of measurable data collected shall be computed to indicate read rate described by the defined measurable above. The Read Rate shall be evaluated and reported as the average (arithmetic mean) of the measured values.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported read rate parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.4.2 Multiple tags

8.4.2.1 Purpose

This test shall evaluate the Read Rate of an RFID system (tag and interrogator). The rate parameter shall consist of a computed measurable representing the tag reading performance of the system as described in clause 0 using multiple tags. This measurable shall be in terms of "tags per second".

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.4.2.2 Test procedure

The tag population (i.e. linear 2D, and/or 3D) shall be placed in responsive part of the read zone as established by the Read Range test above. Multiple sample points within the volume shall be used. A minimum of 10 sample points shall be used.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated. The time from initiation of the activation signal to the completion of the read process (e.g. successfully retrieve all requested tag data) shall be recorded. The completion of the read process shall include the time required to report all requested tag data to application source. The application source may be a human operator, a secured buffer, or a "host" computer where application decisions are handled.

All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

The test shall be repeated (as required) for a moving tag population. For a moving tag population the initiation of the activation signal shall be set to correspond to the sample points. Successful reads shall be recorded.

8.4.2.3 Computation of results

The set of measurable data collected shall be computed to indicate read rate described by the defined measurable above. The Read Rate shall be evaluated and reported as the average (arithmetic mean) of the measured values.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported read rate parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.5 Write range

8.5.1 Individual tag

8.5.1.1 Purpose

This test shall evaluate the Write Range of an RFID system (tag and interrogator). The range parameter shall consist of six computed measured values representing the geometric extent of the write zone (volume) as described in clause 6.4.2 using a single tag. These measured values shall be:

- R(x) extent
- R(y) extent
- R(z) min
- R(z) max

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.5.1.2 Test procedure

The tag shall be moved (relative to the interrogator) in a geometric sampling volume stopping at each sample point. The sample volume shall be of sufficient size to fully encompass the interrogation volume. The sampling volume shall have a sampling resolution of 10 cm or smaller.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated at each sample point. A successful identification shall be defined as the proper unique communication being established between the interrogator and the tag as defined in the RFID air interface protocol. All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

Following successful identification data shall be "written" to the segregated tag. The amount of information shall be defined by the specified test conditions. The sample point is complete upon the successful "writing" of the tag data. Verification of written data shall be performed if required by the protocol. Successful writes shall be recorded.

The test shall be repeated (as required) for a moving tag. For a moving tag the initiation of the activation signal shall be set to correspond to the sample points. Successful writes shall be recorded.

8.5.1.3 Computation of results

The set of measurable data collected shall be computed to indicate write volume described by the defined measured values above. The Write Range shall be evaluated based on a 100% success criterion. If the write zone contains regions (voids) where less than a 100% success identification criterion was measured, the quantity and size of these regions shall be recorded.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported write range parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.5.2 Multiple tags

8.5.2.1 Purpose

This test shall evaluate the Write Range of an RFID system (tag and interrogator). The range parameter shall consist of six computed measured values representing the geometric extent of the write zone (volume) as described in clause 6.4.2 using multiple tags. These measured values shall be:

- R(x) extent
- R(y) extent
- R(z) min
- R(z) max

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.5.2.2 Test procedure

The tag population (i.e. linear 2D, and/or 3D) shall be moved (relative to the interrogator) in a geometric sampling volume stopping at each sample point. The sample volume shall be of sufficient size to fully encompass the interrogation volume. The sampling volume shall have a sampling resolution of 10 cm or smaller.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated at each sample point. A successful identification shall be defined as the proper unique communication being established between the interrogator and all the tags as defined in the RFID air interface protocol. All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

Following successful identification data shall be "written" to the segregated tag. The amount of information shall be defined by the specified test conditions. The sample point is complete upon the successful "writing" of the tag population data. Successful writes shall be recorded.

The test shall be repeated (as required) for a moving tag population. For a moving tag population the initiation of the activation signal shall be set to correspond to the sample points. Successful writes shall be recorded.

8.5.2.3 Computation of results

The set of measurable data collected shall be computed to indicate write volume described by the defined measured values above. The Write Range shall be evaluated based on a 100% success criterion. If the write zone contains regions (voids) where less than a 100% success identification criterion was measured, the quantity and size of these regions shall be recorded.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported write range parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.6 Write rate

8.6.1 Individual tag

8.6.1.1 Purpose

This test shall evaluate the Write Rate of an RFID system (tag and interrogator). The rate parameter shall consist of a computed measurable representing the tag writing performance of the system as described in clause 0 using a single tag. This measurable shall be in terms of "tags per second".

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.6.1.2 Test procedure

The tag shall be placed in responsive part of the write zone as established by the Write Range test above. Multiple sample points within the volume shall be used.A minimum of 10 sample points shall be used.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated. The time from initiation of the activation signal to the completion of the write process (e.g. successfully write all requested tag data) shall be recorded. The completion of the write process shall include the time required to report all successful writing all requested tag data to application source. The application source may be a human operator, a secured buffer, or a "host" computer where application decisions are handled.

All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

The test shall be repeated (as required) for a moving tag. For a moving tag the initiation of the activation signal shall be set to correspond to the sample points. Successful writes shall be recorded.

8.6.1.3 Computation of results

The set of measurable data collected shall be computed to indicate write rate described by the defined measurable above. The Write Rate shall be evaluated and reported as the average (arithmetic mean) of the measured values.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported write rate parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

8.6.2 Multiple tags

8.6.2.1 Purpose

This test shall evaluate the Write Rate of an RFID system (tag and interrogator). The rate parameter shall consist of a computed measurable representing the tag writing performance of the system as described in clause 0 using multiple tags. This measurable shall be in terms of "tags per second".

Multiple samples of each measurable shall be collected for each test condition under evaluation. A minimum of 10 samples shall be collected.

8.6.2.2 Test procedure

The tag population (i.e. linear 2D, and/or 3D) shall be placed in responsive part of the write zone as established by the Write Range test above. Multiple sample points within the volume shall be used. A minimum of 10 sample points shall be used.

The appropriate activation signal (based on the RFID air interface protocol defined in the relevant part of ISO/IEC 18000) shall be initiated. The time from initiation of the activation signal to the completion of the write process (e.g. successfully write all requested tag data) shall be recorded. The completion of the write process shall include the time required to report successful writing of all requested tag data to application source. The application source may be a human operator, a secured buffer, or a "host" computer where application decisions are handled.

All error processing (i.e. retries, timeouts, etc.) shall be set to the defaults defined in the RFID air interface protocol. Where such defaults are undefined, the error processing parameters shall be set as recommended by the manufacturer and recorded.

The test shall be repeated (as required) for a moving tag population. For a moving tag population the initiation of the activation signal shall be set to correspond to the sample points. Successful writes shall be recorded.

8.6.2.3 Computation of results

The set of measurable data collected shall be computed to indicate write rate described by the defined measurable above. The Write Rate shall be evaluated and reported as the average (arithmetic mean) of the measured values.

It is recommended that multiple sets of tags (when the variable is the tag) and interrogators (when the variable is the interrogator) be evaluated when possible due to variations in individual products. When such product sampling is available, the reported write rate parameter shall represent the limiting (minimum/maximum) value measured through the series of tests.

9 Reporting of test results

The results of performance tests performed in accordance with the test methods detailed (or modified to reflect specific user-based applications) in clause 6 above shall be in a tabular form (e.g. matrix) relating the evaluated performance parameters for the specified test conditions. The RF environment shall be reported as documented in the collected test data. Environmental conditions including temperature and humidity shall also be reported. An example is shown below in Table 3.

Table 3 — Test results example

Performance Parameter		**Tag Mounting Material**						**Comments**
			Corrugated paper	**Plywood**	**Plexiglas**	**Aluminium**	**Glass**	
Identification	Range	(x) extent						
		(y) extent						
		(z) minimum						
		(z) maximum						
	Rate							
Read	Range	(x) extent						
		(y) extent						
		(z) minimum						
		(z) maximum						
	Rate							
Write	Range	(x) extent						
		(y) extent						
		(z) minimum						
		(z) maximum						
	Rate							

Annex A
(informative)
Test measurement site

A.1 Test sites and general arrangements for measurements involving the use of radiated fields

A.1.1 General

This annex describes the three most commonly available test sites, an anechoic chamber, an anechoic chamber with a ground plane and an Open Area Test Site (OATS), which may be used for radiated tests. These test sites are generally referred to as free field test sites. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified.

NOTE: To ensure reproducibility and traceability of radiated measurements only these test sites should be used in measurements in accordance with the present document.

A.1.2 Anechoic chamber

An anechoic chamber is an enclosure, usually shielded, whose internal walls, floor and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The chamber usually contains an antenna support at one end and a turntable at the other. A typical anechoic chamber is shown in Figure A.1.

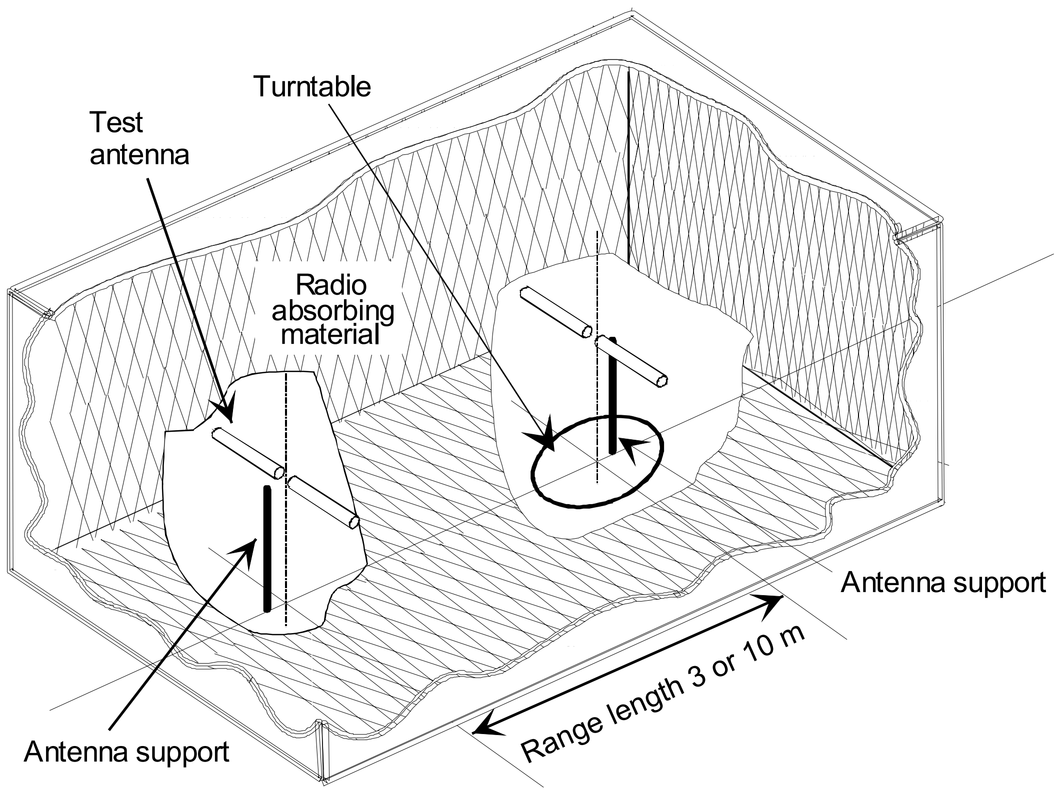


Figure A.1 — A typical anechoic chamber

The chamber shielding and radio absorbing material work together to provide a controlled environment for testing purposes. This type of test chamber attempts to simulate free space conditions.

The shielding provides a test space, with reduced levels of interference from ambient signals and other outside effects, whilst the radio absorbing material minimizes unwanted reflections from the walls and ceiling which can influence the measurements. In practice it is relatively easy for shielding to provide high levels (80 dB to 140 dB) of ambient interference rejection, normally making ambient interference negligible.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a suitable height (e.g. 1 m.) above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2/\lambda$ (m), whichever is greater (see subclause A.2.5). The distance used in actual measurements shall be recorded with the test results.

The anechoic chamber generally has several advantages over other test facilities. There is minimal ambient interference, minimal floor, ceiling and wall reflections and it is independent of the weather. It does however have some disadvantages which include limited measuring distance and limited lower frequency usage due to the size of the pyramidal absorbers. To improve low frequency performance, a combination structure of ferrite tiles and urethane foam absorbers is commonly used.

All types of emission, sensitivity and immunity testing can be carried out within an anechoic chamber without limitation.

A.1.3 Anechoic chamber with a conductive ground plane

An anechoic chamber with a conductive ground plane is an enclosure, usually shielded, whose internal walls and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The floor, which is metallic, is not covered and forms the ground plane. The chamber usually contains an antenna mast at one end and a turntable at the other. A typical anechoic chamber with a conductive ground plane is shown in Figure A.2.

This type of test chamber attempts to simulate an ideal Open Area Test Site whose primary characteristic is a perfectly conducting ground plane of infinite extent.

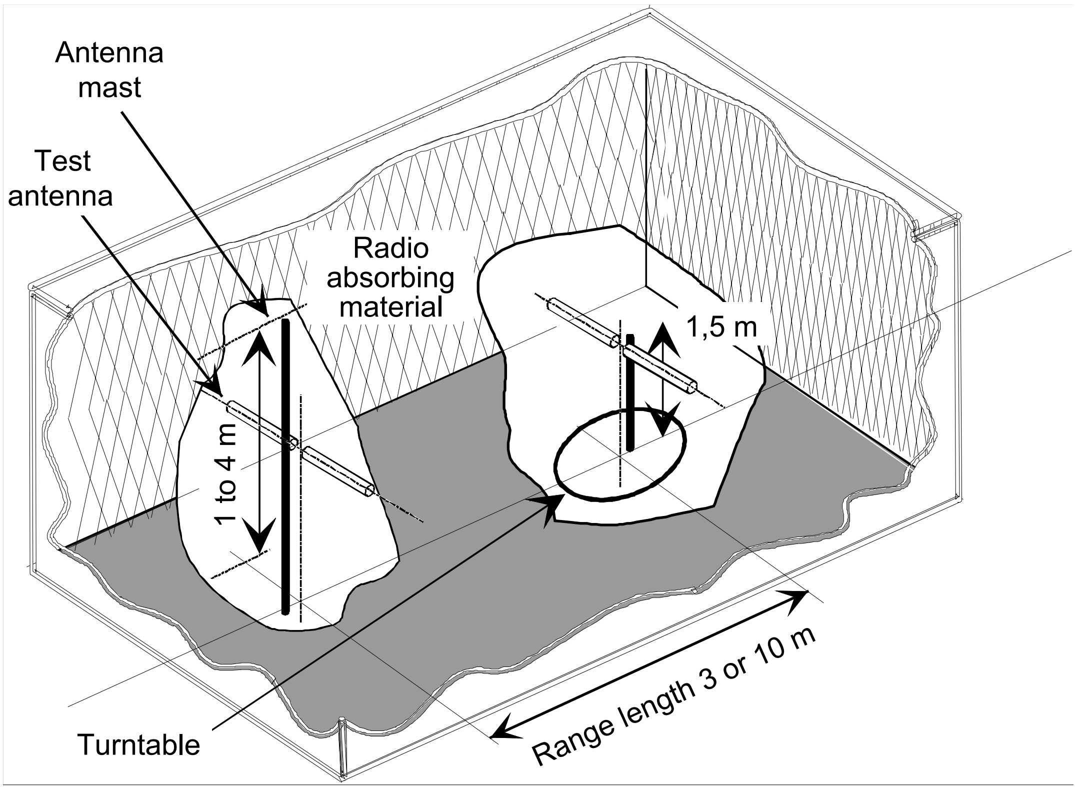


Figure A.2 — A typical anechoic chamber with a conductive ground plane

In this facility the ground plane creates the wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals from both the direct and reflected transmission paths. This creates a unique received signal level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

The antenna mast provides a variable height facility (from 1 m to 4 m) so that the position of the test antenna can be optimized for maximum coupled signal between antennas or between an EUT and the test antenna.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m. above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2/\lambda$ (m), whichever is greater (see subclause A.2.4). The distance used in actual measurements shall be recorded with the test results.

Emission testing involves firstly 'peaking' the field strength from the EUT by raising and lowering the receiving antenna on the mast (to obtain the maximum constructive interference of the direct and reflected signals from the EUT) and then rotating the turntable for a 'peak' in the azimuth plane. At this height of the test antenna on the mast, the amplitude of the received signal is noted. Secondly the EUT is replaced by a substitution antenna (positioned at the EUT's phase or volume centre) which is connected to a signal generator. The signal is again 'peaked' and the signal generator output adjusted until the level, noted in stage one, is again measured on the receiving device.

Receiver sensitivity tests over a ground plane also involve 'peaking' the field strength by raising and lowering the test antenna on the mast to obtain the maximum constructive interference of the direct and reflected signals, this time using a measuring antenna which has been positioned where the phase or volume centre of the EUT will be during testing. A transform factor is derived. The test antenna remains at the same height for stage two, during which the measuring antenna is replaced by the EUT. The amplitude of the transmitted signal is reduced to determine the field strength level at which a specified response is obtained from the EUT.

A.1.4 Open area test site (OATS)

An Open Area Test Site comprises a turntable at one end and an antenna mast of variable height at the other end above a ground plane, which in the ideal case, is perfectly conducting and of infinite extent. In practice, whilst good conductivity can be achieved, the ground plane size has to be limited. A typical Open Area Test Site is shown in Figure A.3.

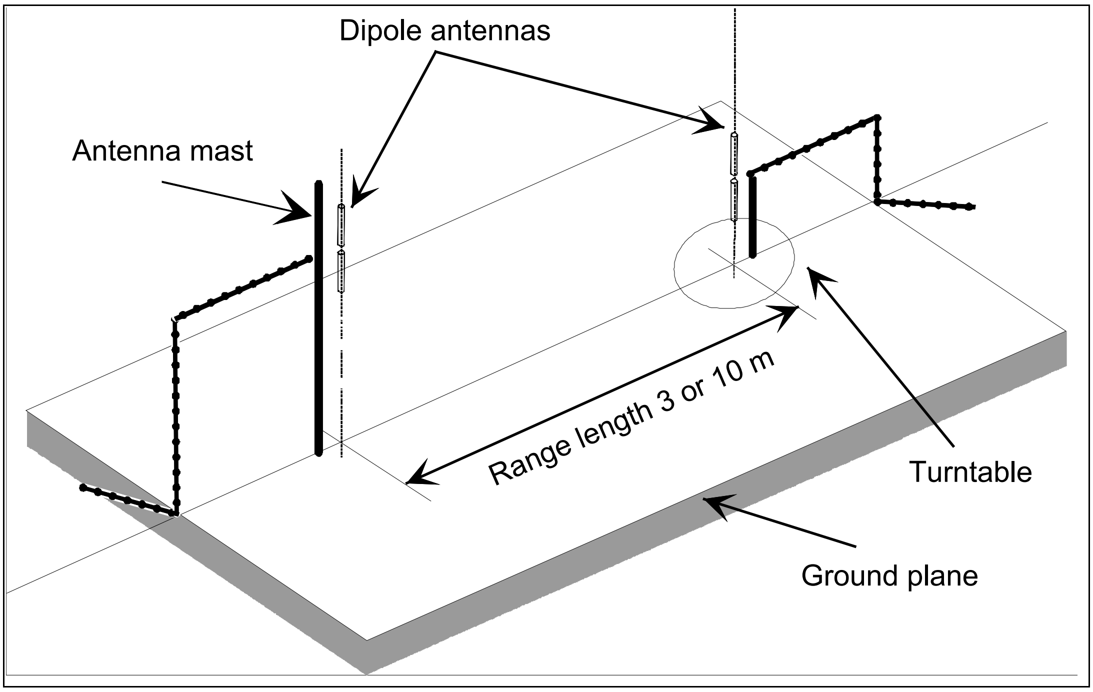


Figure A.3 — A typical Open Area Test Site

The ground plane creates a wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals received from the direct and reflected transmission paths. The phasing of these two signals creates a unique received level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

Site qualification concerning antenna positions, turntable, measurement distance and other arrangements are same as for anechoic chamber with a ground plane. In radiated measurements an OATS is also used by the same way as anechoic chamber with a ground plane.

Typical measuring arrangement common for ground plane test sites is presented in the Figure A.4.

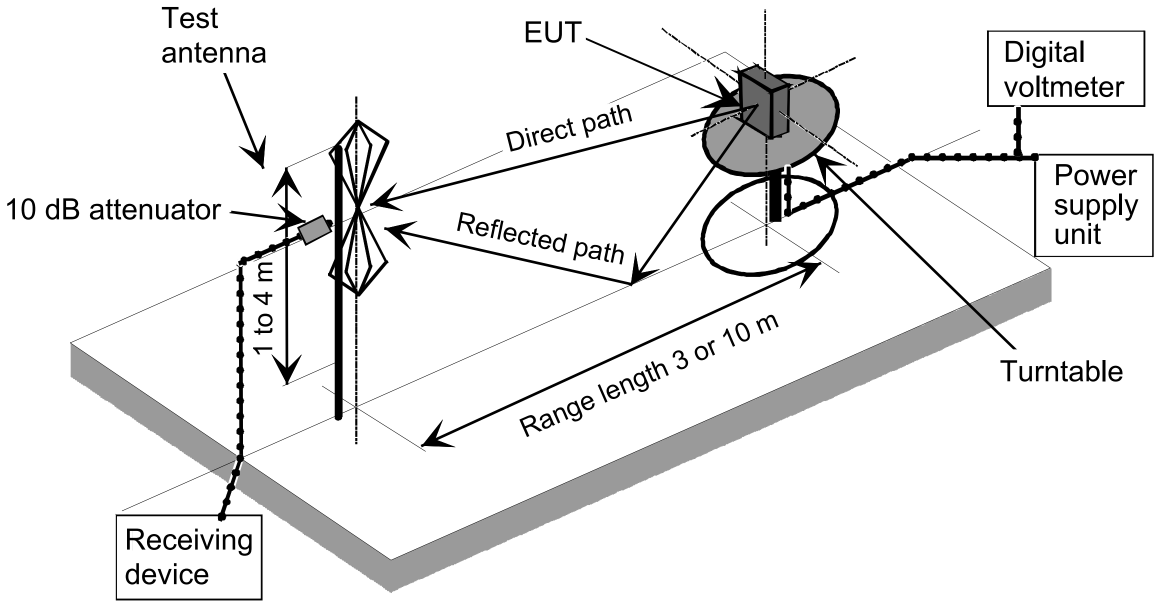


Figure A.4 — Measuring arrangement on ground plane test site (OATS set-up for spurious emission testing)

A.1.5 Test antenna

A test antenna is always used in radiated test methods. In emission tests (i.e. frequency error, effective radiated power, spurious emissions and adjacent channel power) the test antenna is used to detect the field from the EUT in one stage of the measurement and from the substitution antenna in the other stage. When the test site is used for the measurement of receiver characteristics (i.e. sensitivity and various immunity parameters) the antenna is used as the transmitting device.

The test antenna should be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization which, on ground plane sites (i.e. anechoic chambers with ground planes and Open Area Test Sites), should additionally allow the height of its centre above the ground to be varied over the specified range (usually 1 to 4 metres).

In the frequency band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5 [9]) are generally recommended. For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For spurious emission testing, however, a combination of bicones and log periodic dipole array antennas (commonly termed 'log periodics') could be used to cover the entire 30 MHz to 1 000 MHz band. Above 1 000 MHz, waveguide horns are recommended although, again, log periodics could be used.

NOTE: The gain of a horn antenna is generally expressed relative to an isotropic radiator.

A.1.6 Substitution antenna

The substitution antenna is used to replace the EUT for tests in which a transmitting parameter (i.e. frequency error, effective radiated power, spurious emissions and adjacent channel power) is being measured. For measurements in the frequency band 30 MHz to 1 000 MHz, the substitution antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [9]). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For measurements above 1 000 MHz, a waveguide horn is recommended. The centre of this antenna should coincide with either the phase centre or volume centre.

A.1.7 Measuring antenna

The measuring antenna is used in tests on an EUT in which a receiving parameter (i.e. sensitivity and various immunity tests) is being measured. Its purpose is to enable a measurement of the electric filed strength in the vicinity of the EUT. For measurements in the frequency band 30 MHz to 1 000 MHz, the measuring antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [9]. For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. The centre of this antenna should coincide with either the phase centre or volume centre (as specified in the test method) of the EUT.

A.1.8 Stripline arrangement

A.1.8.1 General

The stripline arrangement is a RF coupling device for coupling the integral antenna of an equipment to a 50 Ω radio frequency terminal. This allows the radiated measurements to be performed without an open air test site but in a restricted frequency range. Absolute or relative measurements can be performed; absolute measurements require a calibration of the stripline arrangement.

A.1.8.2 Description

The stripline is made of three highly conductive sheets forming part of a transmission line which allows the equipment under test to be placed within a known electric field. They shall be sufficiently rigid to support the equipment under test.

Two examples of stripline characteristics are given below:

	IEC 489-3 App. J		FTZ No512 TB 9
Useful frequency range	MHz	1 to 200	0,1 to 4000
Equipment size limits	length	200 mm	1 200 mm
(antenna included):	width	200 mm	1 200 mm
	height	250 mm	400 mm

A.1.8.3 Calibration

The aim of calibration is to establish at any frequency a relationship between the voltage applied by the signal generator and the field strength at the designated test area inside the stripline.

A.1.8.4 Mode of use

The stripline arrangement may be used for all radiated measurements within its calibrated frequency range.

The method of measurement is the same as the method using an open air test site with the following change. The stripline arrangement input socket is used instead of the test antenna.

A.2 Guidance on the use of radiation test sites

A.2.1 General

This clause details procedures, test equipment arrangements and verification that should be carried out before any of the radiated tests are undertaken. These schemes are common to all types of test sites described in Annex A.

A.2.2 Verification of the test site

No test should be carried out on a test site which does not possess a valid certificate of verification. The verification procedures for the different types of test sites described in Annex A (i.e. anechoic chamber, anechoic chamber with a ground plane and Open Area Test Site) are given in TR 102 273 [8] Parts 2, 3 and 4, respectively.

A.2.3 Preparation of the EUT

The manufacturer should supply information about the EUT covering the operating frequency, polarization, supply voltage(s) and the reference face. Additional information, specific to the type of EUT should include, where relevant, carrier power, channel separation, whether different operating modes are available (e.g. high and low power modes) and if operation is continuous or is subject to a maximum test duty cycle (e.g. 1 minute on, 4 minutes off).

Where necessary, a mounting bracket of minimal size should be available for mounting the EUT on the turntable. This bracket should be made from low conductivity, low relative dielectric constant (i.e. less than 1,5) material(s) such as expanded polystyrene, balsa wood, etc.

A.2.4 Power supplies to the EUT

All tests should be performed using power supplies wherever possible, including tests on EUT designed for battery-only use. In all cases, power leads should be connected to the EUT's supply terminals (and monitored with a digital voltmeter) but the battery should remain present, electrically isolated from the rest of the equipment, possibly by putting tape over its contacts.

The presence of these power cables can, however, affect the measured performance of the EUT. For this reason, they should be made to be "transparent" as far as the testing is concerned. This can be achieved by routing them away from the EUT and down to the either the screen, ground plane or facility wall (as appropriate) by the shortest possible paths. Precautions should be taken to minimize pick-up on these leads (e.g. the leads could be twisted together, loaded with ferrite beads at 0,15 m spacing or otherwise loaded).

A.2.5 Range length

The range length for all these types of test facility should be adequate to allow for testing in the far-field of the EUT i.e. it should be equal to or exceed:

$$\frac{2(d_1 + d_2)^2}{\lambda}$$

where:

d_1 is the largest dimension of the EUT/dipole after substitution (m);

d_2 is the largest dimension of the test antenna (m);

λ is the test frequency wavelength (m).

It should be noted that in the substitution part of this measurement, where both test and substitution antennas are half wavelength dipoles, this minimum range length for far-field testing would be:

$$2\lambda$$

It should be noted in the test report when either of these conditions is not met so that the additional measurement uncertainty can be incorporated into the results.

NOTE 1: For the fully anechoic chamber, no part of the volume of the EUT should, at any angle of rotation of the turntable, fall outside the "quiet zone" of the chamber at the nominal frequency of the test.

NOTE 2: The "quiet zone" is a volume within the anechoic chamber (without a ground plane) in which a specified performance has either been proven by test, or is guaranteed by the designer/manufacture. The specified performance is usually the reflectivity of the absorbing panels or a directly related parameter (e.g. signal uniformity in amplitude and phase). It should be noted however that the defining levels of the quiet zone tend to vary.

NOTE 3: For the anechoic chamber with a ground plane, a full height scanning capability, i.e. 1 to 4 m, should be available for which no part of the test antenna should come within 1 m of the absorbing panels. For both types of Anechoic Chamber, the reflectivity of the absorbing panels should not be worse than -5 dB.

NOTE 4: For both the anechoic chamber with a ground plane and the Open Area Test Site, no part of any antenna should come within 0,25 m of the ground plane at any time throughout the tests. Where any of these conditions cannot be met, measurements should not be carried out.

A.2.6 Site preparation

The cables for both ends of the test site should be routed horizontally away from the testing area for a minimum of 2 m (unless, in the case both types of anechoic chamber, a back wall is reached) and then allowed to drop vertically and out through either the ground plane or screen (as appropriate) to the test equipment. Precautions should be taken to minimize pick up on these leads (e.g. dressing with ferrite beads, or other loading). The cables, their routing and dressing should be identical to the verification set-up.

NOTE: For ground reflection test sites (i.e. anechoic chambers with ground planes and Open Area Test Sites) which incorporate a cable drum with the antenna mast, the 2 m requirement may be impossible to comply with.

Calibration data for all items of test equipment should be available and valid. For test, substitution and measuring antennas, the data should include gain relative to an isotropic radiator (or antenna factor) for the frequency of test. Also, the VSWR of the substitution and measuring antennas should be known.

The calibration data on all cables and attenuators should include insertion loss and VSWR throughout the entire frequency range of the tests. All VSWR and insertion loss figures should be recorded in the log book results sheet for the specific test.

Where correction factors/tables are required, these should be immediately available.

For all items of test equipment, the maximum errors they exhibit should be known along with the distribution of the error e.g.:

- cable loss: ± 0,5 dB with a rectangular distribution;
- measuring receiver: 1,0 dB (standard deviation) signal level accuracy with a Gaussian error distribution.

At the start of measurements, system checks should be made on the items of test equipment used on the test site.

A.3 Coupling of signals

A.3.1 General

The presence of leads in the radiated field may cause a disturbance of that field and lead to additional measurement uncertainty. These disturbances can be minimized by using suitable coupling methods, offering signal isolation and minimum field disturbance (e.g. optical and acoustic coupling).

A.3.2 Data signals

Isolation can be provided by the use of optical, ultra sonic or infra red means. Field disturbance can be minimized by using a suitable fibre optic connection. Ultra sonic or infra red radiated connections require suitable measures for the minimization of ambient noise.

A.4 Standard test position

The standard position in all test sites, except the stripline arrangement, for equipment which is not intended to be worn on a person, including hand held equipment, shall be on a non conducting support, height 1,5 m, capable of rotating about a vertical axis through the equipment. The standard position of the equipment shall be the following:

a) for equipment with an internal antenna, it shall be placed in the position closest to normal use as declared by the manufacturer;

b) for equipment with a rigid external antenna, the antenna shall be vertical;

c) for equipment with a non rigid external antenna, the antenna shall be extended vertically upwards by a non conducting support.

Equipment which is intended to be worn on a person may be tested using a simulated man as support.

The simulated man comprises a rotatable acrylic tube filled with salt water, placed on the ground.

The container shall have the following dimensions:

- Height: 1,7 ± 0,1 m;
- Inside diameter: 300 ± 5 mm;
- Sidewall thickness: 5 ± 0,5 mm.

The container shall be filled with a salt (NaCl) solution of 1,5 g per litre of distilled water.

The equipment shall be fixed to the surface of the simulated man, at the appropriate height for the equipment.

NOTE To reduce the weight of the simulated man it may be possible to use an alternative tube which has a hollow centre of 220 mm maximum diameter.

In the stripline arrangement the equipment under test or the substitution antenna is placed in the designated test area in the normal operational position, relative to the applied field, on a pedestal made of a low dielectric material (dielectric constant less than 2).

A.5 Test fixture

A.5.1 General

The test fixture is only needed for the assessment of integral antenna equipment

A.5.2 Description

The test fixture is a radio frequency coupling device associated with an integral antenna equipment for coupling the integral antenna to a 50 Ω radio frequency terminal at the working frequencies of the equipment under test. This allows certain measurements to be performed using the conducted measurement methods. Only relative measurements may be performed and only those at or near frequencies for which the test fixture has been calibrated.

In addition, the test fixture may provide:

a) a connection to an external power supply;

b) in the case of assessment of speech equipment, an audio interface either by direct connection or by an acoustic coupler.

In the case of non-speech equipment, the test fixture can also provide the suitable coupling means e.g. for the data output.

The test fixture shall normally be provided by the manufacturer.

The performance characteristics of the test fixture shall be approved by the testing laboratory and shall conform to the following basic parameters:

a) the coupling loss shall not be greater than 30 dB;

b) a coupling loss variation over the frequency range used in the measurement which does not exceed 2 dB;

c) circuitry associated with the RF coupling shall contain no active or non-linear devices;

d) the VSWR at the 50 Ω socket shall not be more than 1,5 over the frequency range of the measurements;

e) the coupling loss shall be independent of the position of the test fixture and be unaffected by the proximity of surrounding objects or people. The coupling loss shall be reproducible when the equipment under test is removed and replaced;

f) the coupling loss shall remain substantially constant when the environmental conditions are varied.

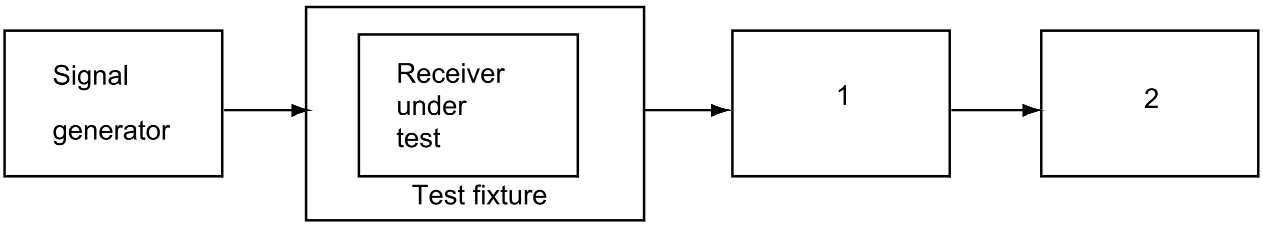
The characteristics and calibration shall be included in the test report.

A.5.3 Calibration

The calibration of the test fixture establishes a relationship between the output of the signal generator and the field strength applied to the equipment placed in the test fixture.

The calibration is valid only at a given frequency and for a given polarization of the reference field.

The actual set-up used depends on the type of the equipment (e.g. data, speech etc.)



1) Coupling device,

2) Device for assessing the performance, e.g. distortion factor, BER measuring device etc.

Figure A.5 — Measuring arrangement for calibration

Method of calibration:

a) Measure the sensitivity expressed as a field strength, as specified in the present document and note the value of this field strength in dBμV/m and the polarization used.

b) Place the receiver in the test fixture which is connected to the signal generator. The level of the signal generator producing:

- a bit error ratio of 0,01, or
- a message acceptance ratio of 80 %, as appropriate,

shall be noted.

The calibration of the test fixture is the relationship between the field strength in dBμV/m and the signal generator level in dBμV emf. This relationship is expected to be linear.

A.5.4 Mode of use

The test fixture may be used to facilitate some of the measurements in the case of equipment having an integral antenna.

It is used in particular for the measurement of the radiated carrier power and usable sensitivity expressed as a field strength under extreme conditions.

For the transmitter measurements calibration is not required as relative measuring methods are used.

For the receiver measurements calibration is necessary as absolute measurements are used.

To apply the specified wanted signal level expressed in field strength, convert it into the signal generator level (emf) using the calibration of the test fixture. Apply this value to the signal generator.

Annex B
(normative)
Test extensions & deviations for long range RFID systems

B.1 Test modifications for long range RFID devices

This annex describes test modifications to accommodate testing long-range, battery-powered RFID systems with read/write ranges significantly exceeding 10 metres. This includes active tags and semi-passive RFID tags.

This annex describes extensions and modifications to Paragraph 8.0, Test Methods and Annex A, Test Measurement Site for long-range RFID systems.

B.2 Test methods

B.2.1 Test method modifications

The Test methods of the following paragraphs shall be conducted using a Test Measurement Site defined by Annex A, with a test sampling resolution of 5 metres or less:

8.1.1 Identification range, Individual tag

8.1.2 Identification range, Multiple tags

8.3.1 Read range, Individual tag

8.3.2 Read range, Multiple tags

8.5.1 Write range, Individual tag

8.5.2 Write range, Multiple tags

In addition, the following performance tests will also be performed, using a Test Measurement Site defined by Annex A, at appropriate test sampling locations.

8.2.1 Identification rate, Individual tag

8.2.2 Identification rate, Multiple tags

8.4.1 Read rate, Individual tag

8.4.2 Read rate, Multiple tags

8.6.1 Write rate, Individual tag

8.6.2 Write rate, Multiple tags

B.2.2 Test method extensions

In addition to the tests defined in B.2.1, the long-range RFID system tests shall be repeated at longer ranges than defined in Annex A and at Test Sites that may or may not have calibrated test areas with ground planes. It is desired that the test site have a low background noise in the frequency bands being utilized by the RFID system. It is required that a calibrated Spectrum Analyzer be used at all test sample points to measure and record background noise spectrum levels before and after RFID test samples.

The Test methods of the following paragraphs shall be conducted with a test sampling resolution of 10.0 metres or 10% of maximum read range, whichever is less.

8.1.1 Identification range, Individual tag

8.1.2 Identification range, Multiple tags

8.3.1 Read range, Individual tag

8.3.2 Read range, Multiple tags

8.5.1 Write range, Individual tag

8.5.2 Write range, Multiple tags

In addition, the following performance tests will also be performed, using a Test Measurement Site defined by Annex A, at appropriate test sampling locations.

8.2.1 Identification rate, Individual tag

8.2.2 Identification rate, Multiple tags

8.4.1 Read rate, Individual tag

8.4.2 Read rate, Multiple tags

8.6.1 Write rate, Individual tag

8.6.2 Write rate, Multiple tags

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