
**Information technology — Radio
frequency identification for item
management — Implementation
guidelines —**

**Part 1:
RFID-enabled labels and packaging
supporting ISO/IEC 18000-6C**

*Technologies de l'information — Identification radiofréquentielle de
gestion d'article — Lignes directrices de mise en application —*

*Partie 1: Étiquettes adaptées à RFID et emballage contenant
l'ISO/CEI 18000-6C*



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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 24729-1, 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*.

ISO/IEC TR 24729 consists of the following parts, under the general title *Information technology — Radio frequency identification for item management — Implementation guidelines*:

- *Part 1: RFID-enabled labels and packaging supporting ISO/IEC 18000-6C*
- *Part 2: Recycling and RFID tags*

Introduction

This Part of ISO/IEC TR 24729 provides background, reference information, and practical knowledge in the selection and application of passive RFID transponders to transport units and pallets (see Layers 2 and 3 of Figure 1) used to move and distribute commercial packaged goods. This may be accomplished with inlays or conventional labels, tickets and tags *with embedded or attached RFID transponders*. This document does not address applications where the transponder is embedded in the container itself.

The assumptions for this document are:

1. RFID transponders may be placed separately from human- and machine-readable labels or information on to the transport unit or pallet. However, if RFID is to be supplied, it is important to have all three on the transport unit or pallet.
2. RFID transponders will increase in reliability therefore non-reads will be minimized.
3. ISO/IEC TR 24729-2 will describe the disposition of non-readable transponders.

The performance of RFID devices, particularly those operating at UHF frequencies (860-960 MHz) are strongly influenced by the construction of the RFID-enabled label, where it is applied to the object, and the RF characteristics of the underlying object or objects. In this regard, much more care has to be taken in selection and placement of the RFID-enabled label on the object than with a conventional bar code label. This, in turn, requires the additional knowledge and practical guidelines for RFID-enabled label selection and usage provided herein.

Information technology — Radio frequency identification for item management — Implementation guidelines —

Part 1: RFID-enabled labels and packaging supporting ISO/IEC 18000-6C

1 Scope

This Part of ISO/IEC TR 24729 provides guidance on the use of RFID enabled labels and packaging in the supply chain. Guidance is provided for transponder selection, as well as the selection of media, adhesives, facestocks, and inks. Techniques are described to minimize electrostatic discharge and transponder damage. Methods are described to verify transponder data. Placement and attachment guidance is provided for inlays, conveyable cases and containers, palletized/unit load material, as well as non-conveyables and non-palletized materials.

One type of RFID referred to within this document is the EPCglobal Class 1 Generation 2 technology. The “Class” structure originally embraced by EPCglobal has, for the most part, been overtaken by events. Consequently, this technology may be referred to as UHF Gen 2 or by its ISO designation, ISO/IEC 18000, Part 6C.

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 646, *Information technology — ISO 7-bit coded character set for information interchange*

ISO/IEC 13239, *Information technology — Telecommunications and information exchange between systems — High-level data link control (HDLC) procedures*

ISO/IEC 15417, *Information technology — Automatic identification and data capture techniques — Code 128 bar code symbology specification*

ISO/IEC 15418, *Information technology — EAN/UCC Application Identifiers and Fact Data Identifiers and Maintenance*

ISO 15394, *Packaging — Bar code and two-dimensional symbols for shipping, transport and receiving labels*

ISO/IEC 15434, *Information technology — Automatic identification and data capture techniques — Syntax for high-capacity ADC media*

ISO/IEC 15438, *Information technology — Automatic identification and data capture techniques — PDF417 bar code symbology specification*

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

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

ISO/IEC 15962, *Information technology — Radio frequency identification (RFID) for item management — Data protocol: data encoding rules and logical memory functions*

ISO/IEC 16022, *Information technology — Automatic identification and data capture techniques — Data Matrix bar code symbology specification*

ISO/IEC 16388, *Information technology — Automatic identification and data capture techniques — Code 39 bar code symbology specification*

ISO 17363, *Supply chain applications of RFID – Freight containers*

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

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

ISO 17366, *Supply chain applications of RFID – Product packaging*

ISO 17367, *Supply chain applications of RFID – Product tagging*

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

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

ISO/IEC 18004, *Information technology — Automatic identification and data capture techniques — QR Code 2005 bar code symbology specification*

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

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

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

ISO 21067, *Packaging — Vocabulary*

ISO 22742, *Packaging — Linear bar code and two-dimensional symbols for product packaging*

ISO/IEC 24723, *Information technology — Automatic identification and data capture techniques — EAN.UCC Composite bar code symbology specification*

ISO/IEC 24724, *Information technology — Automatic identification and data capture techniques — Reduced Space Symbology (RSS) bar code symbology specification*

ISO/IEC 24728, *Information technology — Automatic identification and data capture techniques — MicroPDF417 bar code symbology specification*

IEC 61000-4-2 Ed. 1.2 b:2001, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test*

ITU Recommendation X.25, *Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit*

FCC Part 15.247, *U.S. Code, Title 47 — Telecommunication Chapter I — Federal Communications Commission, Part 15 — Radio Frequency Devices — Section 15.247 — Operation within the Bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz*

ETSI EN 302 208-1 V1.1.1, *European Standard (Telecommunications series), Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W; Part 1: Technical requirements and methods of measurement*

AIM Global NASAG-0401, v1.4, *AIM Global Standard for the use of the AIM RFID Emblem™ and Index to identify RFID-enabled labels*

GS1 General Specifications

EPC™ Radio-Frequency identity protocols, Class-1 Generation-2 UHF RFID, Protocol for communications at 860 MHz – 960 MHz, Version 1.0.9

EPC Tag Data Standards version 1.3

EPC Tag Data Standards version 1.1, Rev 1.27

MIL-STD-129P, Military Marking for Shipment and Storage

Department of Defense Guide to Uniquely Identifying Items, v1.5

3 Terms and definitions

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

3.1

passive RFID transponder

combination of an RFID integrated circuit (chip) bonded to an antenna, where the antenna is used for both two-way wireless communication and to draw power from the reader RF signal to operate the RFID chip

3.2

inlet dry

RFID transponder (chip and antenna) attached to substrate (typically a clear film) providing a physical means to handle the transponder

3.3

inlet wet

RFID transponder (chip and antenna) attached to a substrate that is coated with a layer of adhesive for attachment to a package

3.4

inlay (inlet wet)

inlet with adhesive, on a release liner, for attaching to another surface

3.5

transport unit

1) cases, sleeves, trays, bundles (Kraft paper or poly wrapped), bags, sacks, rigid containers (tubs, totes, drums etc.)

2) either a transport package or a unit load

[ISO 15394, 4.2]

3.6

primary package

1) first wrap on containment of the product

NOTE In some cases the primary package is the transport unit or the pallet. See Figure 1.

2) packaging designed to come into direct contact with the product

[ISO 21067, 2.2.2]

3.7

media

refers to the physical label, tag or ticket

NOTE Media with passive RFID device (transponder or inlay) *(replaces RFID enabled media in the document)*

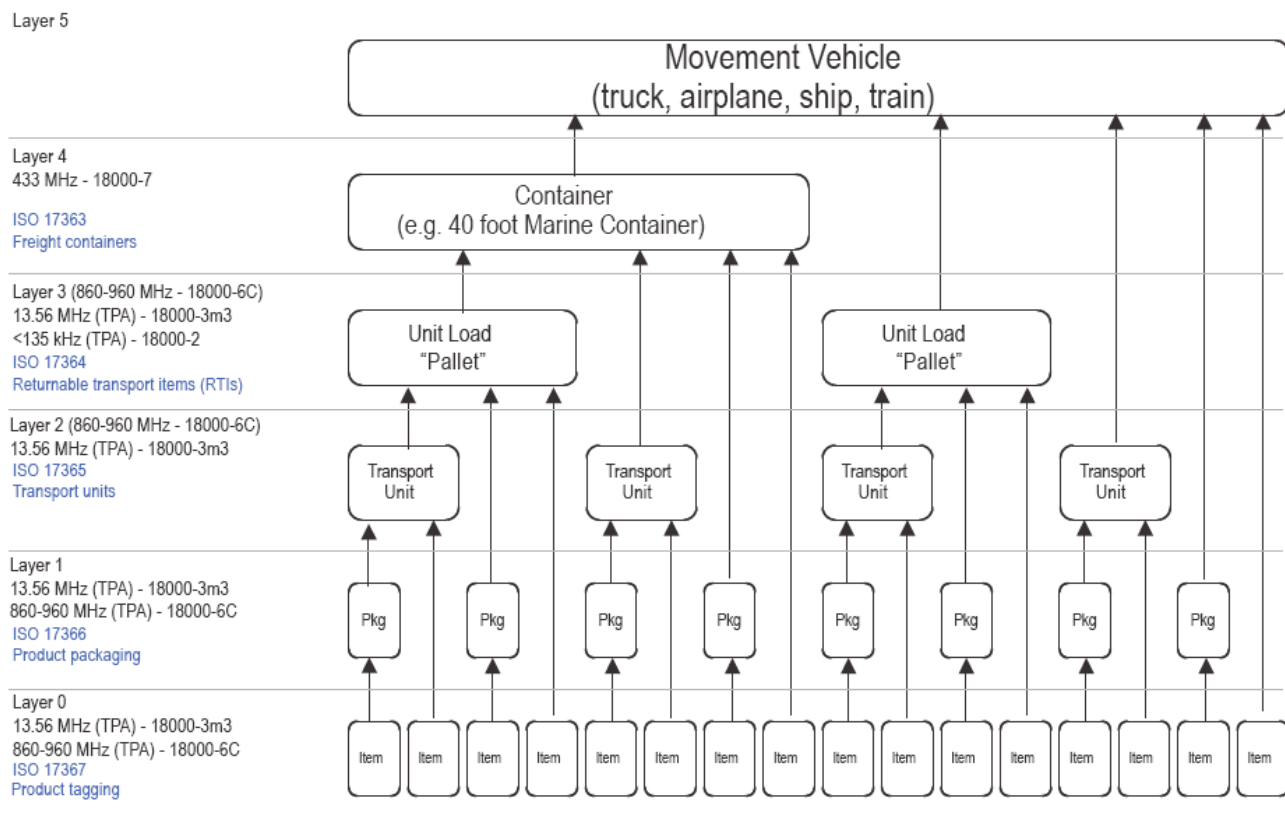


Figure 1 – Supply chain layers of RFID

4 Passive RFID transponder selection

4.1 General

Passive RFID transponder chips operating in the 860 – 960 MHz range should meet the requirements of ISO/IEC 18000, Part 6c.

4.2 Passive UHF transponder frequency considerations

RFID readers are subject to local regulations regarding frequency and allowed reader power. For example, in North America, the nominal operating frequencies are 902-928 MHz, conforming to FCC Part 15.247. In Europe, the nominal operating frequencies are 865-868 MHz, conforming to EN 302-208-1. In Japan, the nominal frequencies are in the range of 950-956 MHz, conforming to the Radio Law of Japan. Local regulations should be consulted before purchasing and deploying UHF RFID readers.

The transponder, when applied to the package, preferably shall be *functional* over the full range of UHF RFID frequencies that are approved for use in most countries, i.e. 860 MHz to 960 MHz. It is acknowledged that the reading performance of a transponder may differ in different regulatory environments.

4.3 UHF transponder design factors

UHF transponder antennas may be fabricated in a number of ways. Antennas produced by each process have different electrical and mechanical properties. It is important to determine that the chosen passive RFID transponders media performs according to the RFID transponder performance specifications when it is mounted on the transport unit or pallet of interest. The key parameter here is the range at which the label and transport unit or pallet (or pallet) combination can be properly read at the required distance and orientation. Standard test methods are described in ISO/IEC 18046. Simplified lab methods are given in Annex C.

4.4 Transponder life and failure modes

The method of transponder construction affects its technical performance, operating life, and environmental compatibility, as well as its cost. Certain special considerations apply.

4.4.1 Flexure and minimum bending radius of the passive RFID transponders media

Depending on the materials and methods used in production of the transponder antenna and the chip bonding method and orientation of the transponder on the substrate, every transponder has a minimum¹ allowed bending radius (radius of curvature). Flexing or bending the finished passive RFID transponders media to a radius smaller than this minimum radius at any point in the application process may result in RFID failure either from antenna fracture or breaking of the chip-antenna bond.

The RFID label manufacturer should be able to provide the value for the minimum-bending radius. In absence of specific information, one practical rule is to never bend the passive RFID transponders labels to a tighter radius than that of the core on which the labels were supplied.

4.4.2 Environmental considerations

Environmental conditions for storage, transportation, and in-use operations should be specified by the user to the manufacturer of the RFID transponders based on the intended usage, e.g. the required working temperature and humidity, and any other unusual environment conditions expected of the object being labelled. The RFID transponder shall survive the same environmental conditions as the material and container onto which the RFID transponder is attached, over its intended working life.

Both extreme limits and cycling of environmental conditions can reduce RFID transponder operating life. Failure modes include chip-bonding failure and antenna fracture, as well as antenna corrosion, electrostatic discharge, etc. Accelerated life testing is recommended before deployment when unusual environmental conditions are expected to determine any limitations on working life of the RFID transponder. These conditions may include outdoor storage; desert heat, arctic cold or freezer storage; nuclear or electromagnetic radiation exposure, chemical wash-down, etc.

5 Media incorporating passive RFID transponders

5.1 General

This clause discusses the materials and construction techniques used in making passive RFID transponders labels and tie-on tags. There are many factors that determine the appropriate design for a given application; whether that design will be environmentally compatible with the intended use, and have stable RFID performance over the required usage life. All of these factors affect media cost.

¹ Three (3) inch diameter is the recommended minimum

5.2 Media configurations

5.2.1 Pressure-sensitive labels

Pressure-sensitive adhesives are widely used in passive RFID transponders media. When properly chosen, these can meet both performance and environmental needs. Annex A contains basic terminology and key design parameters for passive RFID transponders pressure-sensitive labels.

The inlay is attached to the facestock by the facestock adhesive, and the back of the inlay is adhesive coated as well to improve passive RFID transponders media adhesion and prevent an air bubble from forming between the inlay and the transport unit or pallet.

RFID transponders may be inserted into envelopes as an aid to transponder recovery and/or recycling. The envelopes may be attached to the facestock and adhesive coated in a similar manner to direct attachment of a transponder, as above.

5.2.2 Dry-gum (water-activated) adhesive labels

These are *NOT* recommended for use in passive RFID transponders media, because the water required for activation of the adhesive can have an impact on transponder performance. Water molecules attenuate UHF signals, so read range may be adversely affected. Added moisture may result in changing the conductivity of the adhesive, reducing antenna performance. Finally, added moisture may result in corrosion or chemical change in the properties of the antenna material or the chip bond.

5.2.3 Passive RFID transponders tickets used in carrier envelopes

Passive RFID transponders tickets can be inserted in paper or plastic envelopes. These envelopes may be directly attached to transport cases or pallets as a way of applying identification.

The envelopes should preferably be vented to atmospheric air to avoid entrapment of moisture that may condense, whereby preventing transponders from functioning properly; however vents preferably should not compromise the protection afforded by the envelope from general environmental hazards (e.g. rain). An envelope should normally provide additional ESD protection for the transponder. Envelope adhesives should preferably conform to the guidelines in Clause 5.6; however this is less critical than in pressure-sensitive labels as the envelope adhesive is not in contact with the RFID transponder itself. The type of paper or plastic used for these envelopes should be both transparent to UHF radio waves and UV-resistant. Most types of polypropylene, polyethylene, PET and polyester films are reasonably low in attenuation at UHF frequencies. Polyvinyl Chloride (PVC) films should be avoided when utilizing transponders with copper antennas due to potential long-term corrosion of the transponder antenna by the plasticizers.

5.2.4 Tie-on tags

Tie-on tags are passive RFID transponders tickets that are attached with a tie-on. These are often used on non-conveyable materiel. Depending on the situation, a conductive wire tie-on may affect the transponder performance, positively or negatively. UV-resistant plastic (or other non-conductive) tie-ons are generally recommended for use with passive RFID transponders tags.

5.3 Environmental considerations in media design

5.3.1 General

Many Commodity Classes of labelled materiel (including medicines and perishable food items) have highly restricted temperature ranges and operating life. In this case, the passive RFID transponders label need only meet the environmental and working life requirements of the labelled material itself.

5.3.2 Operating and storage temperature ranges of applied passive RFID transponders labels

The following recommendations apply.

Reading temperature range: -40 °C to +70 °C

Storage range (non-reading) -51 °C to +95 °C

5.3.3 Storage of media incorporating passive RFID

Passive RFID transponders labels should be stored in a cool, dry environment sealed in anti-static (non-conductive) bags or cartons. This prevents water or other environmental damage; maintains paper (conductive) moisture balance; prevents adhesive deterioration; and chip damage from electrostatic discharge. Temperature and humidity should be maintained within the limits of the manufacturer's specifications.

5.4 Media printable facestocks

The facestock is the surface of the media that is to be printed. Paper and plastic facestocks may be used with passive RFID. Metal foil, metalized plastics, metal filled plastic, or high UHF attenuation plastics facestocks are not typically used in passive RFID transponders labels as they interfere with RF communication with the transponder.

There are three key issues in selection of a media facestock: printing process compatibility, environmental compatibility with the intended media usage, and physical protection of the transponder from damage. Paper facestock is the lowest cost, but is the least environmentally resistant. UV-resistant plastic and plastic foam facestocks generally provide the best survivability in outdoor and rough service environments, and tend to provide the best protection for the transponder.

5.5 Printing method and ink compatibility

The type of ink or toner used must be matched to the type of printing process used. The ink must also be matched to the selection of the label facestock material to assure good quality of the bar codes printed on the label.

Environmental compatibility and long-term survivability of the printed image are key issues, especially for long-term or outdoor storage applications. Considerations include resistance to water damage, resistance to sunlight and UV-induced fading of the image, and image abrasion or smear resistance.

Most inks have little RF absorption. The supplier of the ribbon or ink should be consulted to ensure that there is no negative impact of printing on RFID performance. A simple test to determine if there is an impact of the ink on RF reading performance is to first measure the maximum reading distance of the unprinted passive RFID label (see Annex C). The label is then put through the intended printing process and the facestock is 100% printed with the intended ink. The maximum label reading distance is then re-measured using the same setup as before. If the maximum read range change is less than 10%, then the ink will have negligible impact on a normally printed (15-25% ink coverage) media passive RFID.

5.6 Permanent label and inlay adhesives

5.6.1 General

Label and inlay adhesives have two sets of properties that must be considered:

- “Initial tack” (ease of initial adhesion) and “settling time” (Number of minutes or hours it takes to form the full-strength permanent bond).
- Ultimate bond strength, i.e. long-term bond stability; environmental stability and aging resistance.

Most adhesives are primarily selected for the second set of properties. There are two basic adhesive families: Acrylic adhesives and rubber-based adhesives. While acrylic adhesives offer the widest range of properties and best high-temperature performance, rubber-based adhesives tend to be lower in cost, offer high initial tack and are often quite adequate for applications such as corrugated case labelling.

The physical and mechanical characteristics of adhesives must meet customer requirements.

5.6.2 Adhesive RF properties and transponder compatibility

The adhesive, since it may be a complex chemical mixture and may also be in direct contact with the transponder antenna, can have strong effects on transponder performance. It may absorb RF energy. Chemical constituents of the adhesive may have a corrosive affect on the antenna (especially etched copper antennas). Also, many adhesives tend to chemically deteriorate with age so that while the adhesive properties may be perfectly acceptable at the time of initial passive RFID transponders label application, after several months or years the effects of adhesive aging may affect the transponder performance. The supplier of the labels should be consulted to assure that the desired label working life is achieved.

5.6.3 Hygroscopic adhesives

Hygroscopic adhesives pick up moisture from the environment and incorporate it. This can result in a number of problems, including negative impact on RFID label performance and/or adhesive failure. Water molecules attenuate UHF signals, so read range may be adversely affected. Finally, added moisture may result in corrosion of the antenna material or the chip bond.

5.7 Removable label adhesives

Removable adhesives are usually not used with passive RFID transponders labels as they may come off unexpectedly during handling. If a removable or re-positionable passive RFID transponders label is desired for special purposes, work with the label supplier to obtain the proper degree of adhesion and life for satisfactory results.

5.8 Release liners (backing) for pressure-sensitive labels and inlays

5.8.1 Purpose

The purpose of a release liner is to carry the passive RFID transponders label during its manufacture and handling to the point that the label is applied to the container.

5.8.2 Adhesive compatibility and release level

Adhesives and release liner coatings are matched to control the force necessary to peel the label from the release liner. Release force must be balanced: high enough so that the stiffer passive RFID transponders labels or inlays nearest the roll core do not separate from the liner, and yet low enough so that the label will peel cleanly in the printer-encoder or label applicator. The depth of the die cut needs to be controlled to prevent compromising the silicon layer and facilitating consistent peel release from the liner when running on automated equipment.

5.8.3 Removing the passive RFID transponders label and inlays from the release liner

A common cause of hidden damage to passive RFID transponders label transponders is carelessness in manually removing the self-adhesive passive RFID transponders label from its release liner. This is because the natural tendency is to peel the label from the liner, resulting in excessive stress and flexure of the transponder antenna, which can cause fracture of the antenna circuit or its bond to the RFID chip. Figure 2 (left) shows this undesirable practice.

Figure 2 (right) shows a better manual method. Lay the passive RFID transponders label face down on a flat surface, and peel the disposable release liner away from the passive RFID transponders label. This minimizes flexure of the transponder.

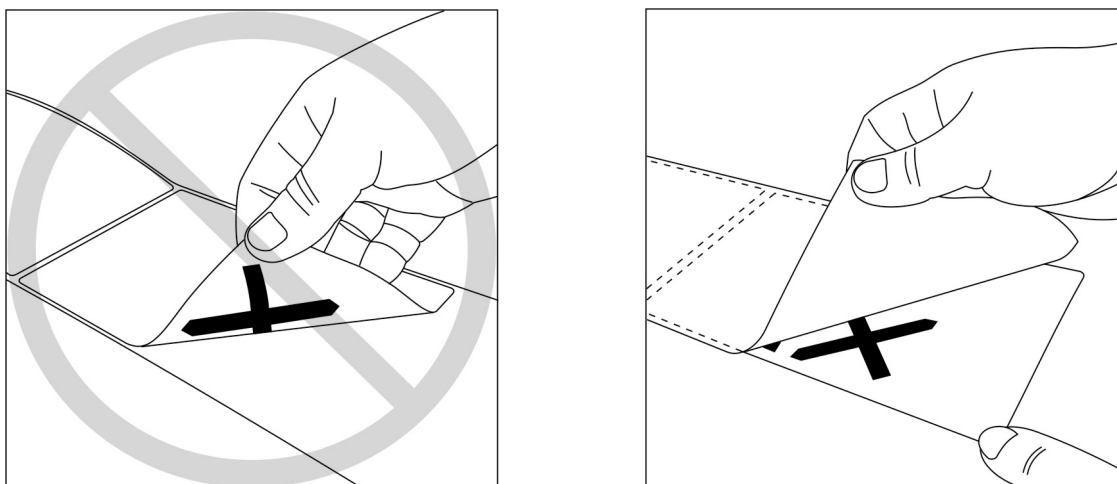


Figure 2 – Incorrect (left) and preferred (right) method of peeling passive RFID transponders labels

Printer encoders or label applicators with the capability of automatically stripping the release liner should be used at the point of label application whenever possible. These are designed to remove the release liner from the label with minimum flexure of the label.

5.8.4 RF properties of release liners

In practice, the RF properties of release liners are relatively unimportant, as the label with passive RFID is removed from the release liner before usage on the container. One place that the RF properties are slightly important during label printing and encoding inside a printer-encoder. However, in this highly controlled environment, signal losses due to RF absorption can easily be compensated. In practice, a slight increase in RF loss due to conductive additives to the silicone release liner to minimize the effects of electrostatic discharge during peeling may be a desirable trade-off.

5.9 Avoiding electrostatic discharge (ESD)

5.9.1 Overview

Many processes can easily generate static electricity, including peeling the label with passive RFID from the release liner. It is especially a problem in low-humidity environments as found in desert, winter or high-altitude conditions. Discharge of static electricity through the transponder antenna into the RFID chip can cause permanent chip failure or loss or corruption of the stored data.

An often-unrecognized source of static electricity (especially in low-humidity environments) is the operator performing the label printing and application. A static charge can build up on the operator, which may be discharged through the passive RFID transponders label as it is removed from the printer or applied to the case or asset. In dry environments and around hazardous materials, labelling operators should work in antistatic environments and wear antistatic clothing and protective gear.

5.9.2 Peeling as a source of static electricity

Peeling the passive RFID transponders label from release liner is a common source of static electricity generation. This occurs whether the label is peeled manually or within a printer or label applicator mechanism. Most printers and applicators have internal methods for safely dissipating the static electricity.

5.9.3 Conveyors as sources of static electricity

Certain types of conveyor belts can build up static electricity as a result of their motion and rubbing against surfaces. This static charge can be transferred to the labelled object causing RFID label damage. The best way to avoid this is by designing or modifying the conveyor system to avoid static electricity build up. Consulting with the conveyor supplier should provide a way to have the static electricity tested and, if found, eliminated.

5.9.4 ESD compliance testing

Electrostatic discharge is clearly a safety issue around explosives, hazardous chemicals and chemical vapours. A statistically significant number of passive RFID transponders labels on packaging should be tested to provide a scientific basis for concluding that the requirement is met. Testing should be done in accordance with IEC 61000-4-2 Ed. 1.2 b: 2001. RFID transponder labels should survive and maintain the integrity of stored data under peak field strength of 50 V/m for 60 s at frequencies ranging from 860 MHz to 960 MHz. Such RFID transponder labels shall further survive and maintain the integrity of stored data after having been subjected to a 25 kilovolt electrostatic discharge.

5.9.5 Printer-encoder considerations

There are two common sources of static electricity generation in printer-encoders: That caused by unwinding or unstacking the facestock, and that arising from unwinding the ribbon. Especially in low humidity environments, a static charge can build up on the label from either source that can discharge into the chip and damage or destroy it. The solution is to safely dissipate the static electricity without damaging the RFID chip. The design of the printer-encoder should eliminate this source of passive RFID transponders label damage.

5.9.5.1 ESD in thermal transfer printers

Thermal transfer ribbons used in many label printers generate static electricity as the polyester film unwinds from the ribbon supply roll. This appears as opposite charges on both sides of the ribbon. Especially in low humidity environments, ensure that the printer has either metal contact or antistatic brushes on the inked side of the ribbon so that the static charge is not dissipated by ESD into the transponder antenna during printing.

5.9.5.2 ESD in Laser and LED printers

The electro-photography methods used in these printers rely on an electrostatic charge on a drum or belt to attract and hold the toner while it is fused to the label stock under heat and/or pressure. These electrostatic processes can contribute to passive RFID transponders label failure through ESD. Typically, there may also be mechanical failures in desktop laser printers from bending the label over small internal rollers. This type of printer should be tested extensively for passive RFID transponders label damage before deployment, especially in low humidity environments.

6 Printing and encoding labels with passive RFID transponders

6.1 Printing methods

Passive RFID transponders labels often contain unique printed information, which is correlated with the unique encoded data in the transponder. The method shall ensure that the printed human-readable, bar codes and the encoded transponder data exactly correlate, both with each other and the database record for the labelled item. Ensure that the design of the label with passive RFID transponder, selection and transponder placement in the label (see Annex A) match the printer-encoder used.

Printer-encoders designed to encode at a minimum the 96-bit EPC data structures GRAI-96, SSCC-96 and SGTIN-96, and the DoD UID-96, specified in the *EPCglobal Tag Data Standard* labels with passive RFID transponders may carry the AIM RFID Emblem "E*" as specified in Annex B. Printer-encoders designed to encode transponders compliant with ISO 17363, 17364, 17365, 17366, or 17367 may carry the AIM RFID Emblem "A*" (for 433 MHz) or "B*" (for 860-960 MHz) as specified in Annex B.

6.2 Label edge start sensing issues

Printer-encoders generally sense either the leading edge of the label facestock; a printed black mark on the back of the label release liner; or a notch or hole. Ensure that the passive RFID transponders label stock and printer-encoder methods are correct for each other. Also see that the label registration sensor has been calibrated against the label stock in use.

6.3 Encoding and/or verifying transponder data

Most printer-encoder systems test the transponder both before and after encoding to validate that the transponder is both functional and that the data was properly encoded. Use of any method or equipment to encode passive RFID transponders labels that does not perform this validation should be avoided.

6.4 Dealing with defective transponders

Printer-encoder systems that test the transponder to validate that the transponder is both functional and the data properly encoded also generally identify labels with defective transponders by printing special marks (such as “void”) on the defective labels. These labels should be disposed of, either manually or automatically, and not used for labelling.

Most of these same printer-encoders will then attempt to encode and print the same information on next passive RFID transponders label automatically, until successful.

When serialized labels are to be prepared, it is recommended to print the label serial number with the same label format program that controls the RFID encoding process. This generally ensures that serial number sequencing is not lost when bad RFID-labels are encountered, and are then reprinted and reprogrammed on the next label.

7 Placement and attachment of media and inlay with passive RFID transponders

7.1 RF influence of the transport unit and its contents on the transponder

At UHF frequencies, packaged objects and packaging materials respond in different ways to the presence of radio waves at different frequencies. Since many non-metallic packaging materials are permeable to UHF frequencies, the RF properties of the contents affect the transponder performance, even when the transponder is placed on the outside of the transport unit. A simple view is that materials and objects may be RF transparent, RF signal reflecting or RF signal absorbing.

- Typically, the effect of conductive RF reflecting materials is to shield or detune the transponder antenna from its resonance frequency so that the antenna can no longer absorb enough RF energy to activate the transponder chip, allowing it to turn on and backscatter data back to the reader.
- Absorbing materials reduce the signal to the transponder by dissipating the RF energy from the reader, causing less energy to be available to power up the chip.
- Chemical composition of an object can result in mixed properties of reflection and absorption

Many objects are a mixture of these properties. Figure 3 shows a triangular graph of the properties, each ranging from 0 to 100%.

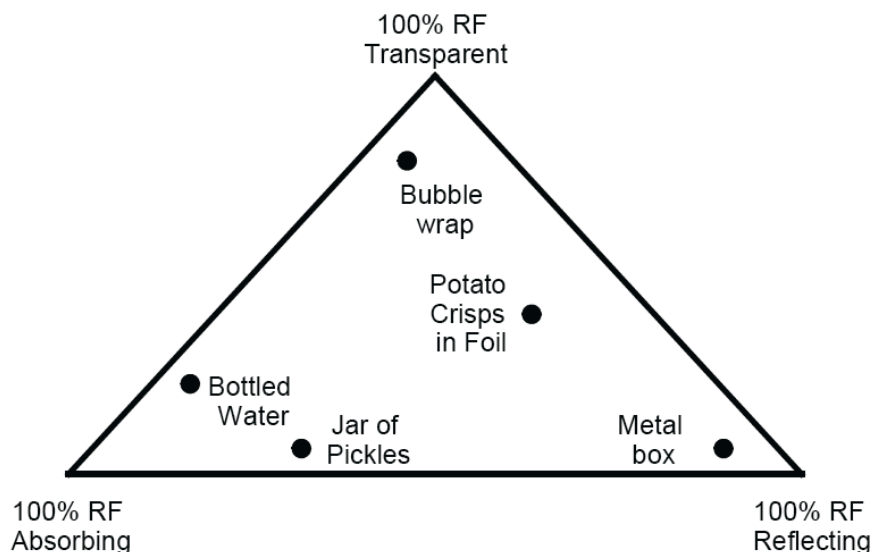


Figure 3 – RF properties of some corrugated cases containing various objects

Imagine a UHF RFID reader with its antenna placed just above the surface of the case where the transponder would be placed at a series of corrugated cases each containing one type of object. Some basic observations:

- Note that the peak of the triangle implies that the transport unit is virtually RF transparent; RF energy is neither absorbed nor reflected. Bubble wrap is only a slight RF absorber.
- Metal objects, like the metal box, are high in RF reflectance but low in absorption.
- Water is a high RF absorber at UHF, but a low RF reflector.
- The pickles in glass jars are excellent RF absorbers, because they contain electrolytes (salt and vinegar) and well as water, but the metal lids are also RF reflectors.
- The foil bags of potato crisps reflect the RF, but because of the non-uniform surface also scatter it in directions other than the incident direction. Thus some of the transport unit's reflected energy is lost, scattering it in random directions.

The fundamental point of the pyramid graph is that the higher the transport unit scores on the pyramid, the less the transport unit influences the reading of the transponder. Qualitatively, those transport units should generally have the longest read range.

One positive way to establish that a passive RFID transponders label works properly on a given type of container is to have a third party test laboratory test and certify it. Alternatively, in-house testing using the simplified methods and apparatus of Annex C will allow a selection of the type and placement of passive RFID transponders label to achieve reasonable transponder read range performance. However, many transport units can be evaluated using a common-sense visual analysis.

7.2 Visual inspection method for determining label or inlay placement

Most transport units (especially if they contain irregularly shaped metal objects) have a mixture of RF reflective and absorbing properties, which are not uniform across the surface of the transport unit. Often, the RF properties are better near the edges. In the example in Figure 4, assume a round metal bucket is packed in a corrugated case, with the top and bottom of the metal bucket nested top and bottom in moulded rigid foam; and the middle of the transport unit is open (air). Figure shows a cross-section of the transport unit bucket.

If passive RFID transponders labels are placed at points A-F on the surface of the case, their relative RF properties due to the influence of the object and its packaging (measured as described above) are shown in

Figure 4. This figure shows a qualitative rating of their estimated RF properties from looking at the transport unit.

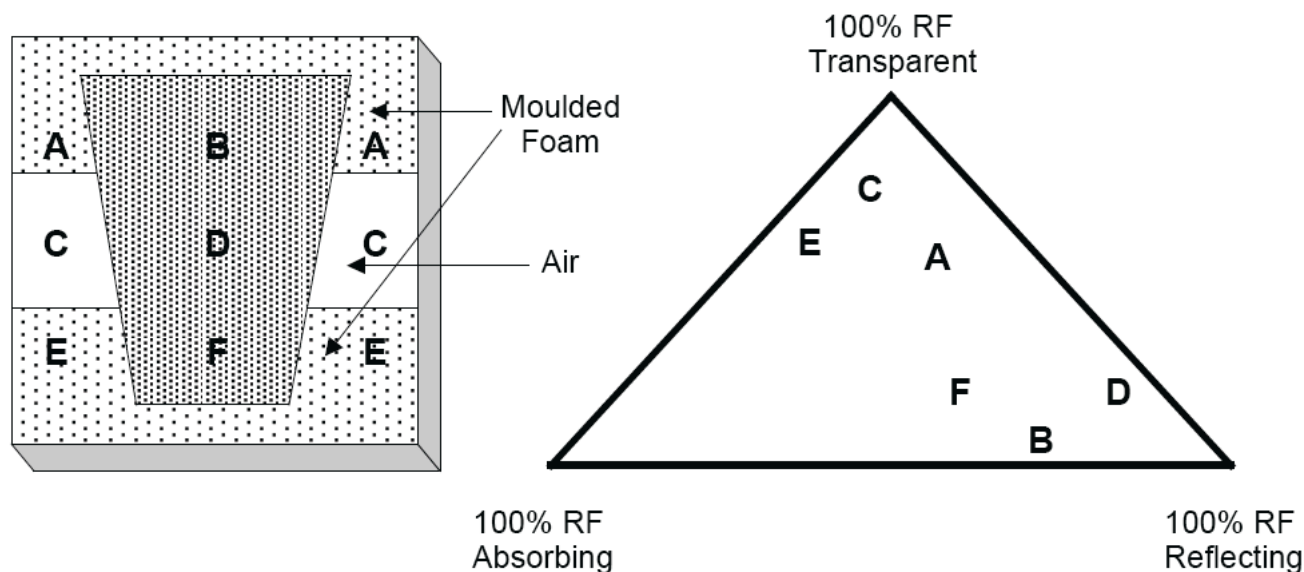


Figure 4 – RF properties map for a corrugated case containing a metal bucket

A UHF reader interrogating passive RFID transponders labels at points A-F sees different RF properties at different places. In this illustration, the moulded foam is RF absorbing while the bucket itself is RF reflecting.

- Point C would experience a small reflective effect from the nearby curved bucket, and little absorption as there is no foam in the area, just air.
- Points A and E would have equal amounts of signal absorption from the full thickness of moulded foam, with point A having a larger reflective component as the bucket diameter is larger at the top than the bottom, and thus closer to points A.
- Point B has the bucket closest to the surface, and thinner foam than point F, so point B is more reflective and has less RF absorption than point F.
- Point D has the bucket further from the surface than point B and has no foam covering it (only air), so it will have both less RF reflection and less RF absorption than point B
- The best place for a passive RFID transponder most likely is point C, as it has the least influence from the bucket in the transport unit.

This gives rise to the rule: "Climb the pyramid" to determine the best label placement

7.3 Transponders for objects primarily acting as RF reflectors

Typically, the effect of reflective objects or metal surfaces is to detune and/or shield the transponder antenna so that the operational range is reduced.

One approach to minimize this impact is to conduct tests to find the place on the transport unit surface where the least amount of reflection occurs, and then determine whether acceptable read range performance can be obtained with a standard transponder located in that position. It is also not unusual, however, for some reflective material in the case to actually improve the performance of a standard transponder by increasing the backscatter signal in certain directions (See Annex C for test methods).

Another approach is to use a transponder specially designed for use on reflective surfaces. These typically use the corrugate itself as a spacer or have an additional foam spacer below the transponder together with a designed resonance frequency so that the effect of the reflective surface is to *retune the transponder's*