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Packaging — Measurement results for the use of RFID on returnable transport items —

Part 2: Plastic returnable transport items

Emballages — Résultats de mesure pour l'utilisation d'étiquettes RFID sur les emballages de transport réutilisables —

Partie 2: Emballages de transport réutilisables en plastique

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 122, *Packaging*.

A list of all parts in the ISO 22251 series can be found on the ISO website.

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

Introduction

The demand for more advanced traceability and reduction in both distribution costs and logistics materials has recently increased in supply chains worldwide, and the use of radio-frequency identification (RFID) in supply chains is regarded as an ideal solution. In actual logistics and material handling, many materials and items are lost or go missing due to the lack of an efficient returnable transport item (RTI) management system, imposing extra costs on companies and enterprises due to additional ordering.

Today, there is strong demand for efficient plastic RTI management especially in the automobile industry where many parts and components are designed exclusively for automotive use. Plastic RTIs are used to store and transport a variety of stored items. In this document, the measurement results of evaluations of RF tag on RTIs for the transport of automotive parts are presented. The results show the changes in durability and communication performance of RF tags attached to plastic RTIs when exposed to various environmental stresses. The results provide insight into the durability of RF tags in various RTI environments and will be useful in many situations where RF tags are attached to plastic RTIs.

Packaging — Measurement results for the use of RFID on returnable transport items —

Part 2:
Plastic returnable transport items

1 Scope

This document summarizes measurement results for the use of RFID on plastic returnable transport items (RTIs).

This document describes the followings:

— materials of plastic RTIs,

— features, reliability of RFID used for plastic RTIs, and

— measurement results for the use of RFID on plastic RTIs.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 445, *Pallets for materials handling — Vocabulary*

ISO 21067 (all parts), *Packaging — Vocabulary*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762, ISO 445, the ISO 21067 series and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
serial number
SN
codes, such as sequential numbers, used for uniqueness

Note 1 to entry: The structure of the serial number can be decided by the company that is under the control of the issuing agency. This is normally composed of an item number and its production number (serial number).

3.2 Abbreviated terms

ETSI European Telecommunications Standards Institute

FCC Federal Communications Commission

PE polyethylene

PP polypropylene

RSSI received signal strength indicator

SUS stainless steel

4 Characteristics of RFID for plastic RTIs

4.1 General

When RF tags are attached to inexpensive plastic RTIs used for various purposes and RFID is used for operation management, the following points are considered.

— First, RF tags attached to inexpensive plastic RTIs also need to be low cost, but inexpensive RF tags marketed for general use are generally manufactured for use in the distribution industry, so it is unclear whether they are reliable enough for long-term use when attached to plastic RTIs. For example, price tag labels are attached to RF tags used in the distribution industry, but because they are used in one-way disposable applications, the conditions for attaching them are very different from plastic RTIs for returnable applications.

— Also, since plastic RTIs are generally transported using conveyor belts and forklifts, RF tags are subject to various forms of physical stress, such as vibration, impact, rough handling of plastic RTIs by operators, and shrinkage of plastic material due to temperature changes. In addition, they are also exposed to chemical stresses from chemicals and plastic RTI washing. However, few evaluations have been performed to assess the extent to which commercially available RF tags attached to RTIs are affected by stresses attached to plastic RTIs during transport and washing.

— As used RF tags are generally incinerated or dissolved, the safety of written data is not considered. In addition, for example, as the data of RF tags used in the automobile industry is common data based on ISO standards, there is no problem even if the data is leaked. However, if security information other than ISO standards is written, it is desirable to destroy used RF tags and IC chips so that the information cannot be read, and to incinerate or dissolve them.

4.2 Unit reliability evaluations

4.2.1 Overview of test methods

RF tags attached to plastic RTIs are subject to physical stresses such as vibrations, shocks, rough handling of plastic RTIs, temperature changes, and chemical stresses due to chemicals and washing during parts transport.

Therefore, 7 kinds of commercially available RF tags were attached to the materials used for plastic RTI, and 14 kinds of tests (see Table 1 " Summary of main results ") were conducted under the assumed conditions to evaluate the physical and the performance changes of the RF tags after the tests.

4.2.2 Plastic RTI types and materials

Plastic RTI includes special types such as containers, pallets, folding containers, and dunnages, but the materials themselves are broadly divided into PE and PP materials. (See Annex A Examples of Plastic RTIs for Supply Chain)

The majority of plastic RTIs used in various applications are made of PP, but some are made of PE. PE has better shock resistance at low temperatures than PP and is used in low-temperature environments such as the fishing industry and food industry. However, because of its low cost, light weight, rigidity, moldability and heat resistance, PP is the plastic material of choice except for special applications such as refrigerated warehouses.

— PP consists of homopolymers with high rigidity and high heat-resistance, random copolymers with high transparency and high flexibility, and block copolymers with high shock-resistance, and is mainly used for plastic returnable containers.

— PE is available in low-density, medium-density and high-density types. The high-density type is mainly used for plastic returnable containers.

Plastic RTIs include antistatic RTIs used for storing and transporting electronic components sensitive to static electricity; however, they are generally used less frequently and have fewer applications than general-purpose plastic RTIs, as such, they were not evaluated here. Further, the influence of the dielectric constant on the reading of the RF tag when the RF tag is attached to the plastic is not as serious as when the RF tag is attached to the metal, hence, it is not an issue. Since plastic RTIs can be used for many years, we evaluated how RF tags attached to such materials aged.

4.2.3 Main evaluation results

Table 1 shows the evaluation results of the general-purpose RF tags attached to plastic RTIs and plastic boards. For more information on evaluation RF tag samples, evaluation methods, and results, see Annex B and Annex C.

Table 1 — Summary of main results

	Test item	Reference standard	Measurement conditions	Results	Refer to
1	Water immersion test	IPX8 or equivalent	Immersed at 1,2 m for 1 hr.	— Depending on the RF tag material, the RF tag material could become transparent due to penetration of water, or RF tags attached to PP boards could fail to communicate.	Annex B.10
2	Chemical resistance test	—	Immersed for 2 hrs.	— Depending on the RF tag material, some RF tag materials became transparent due to penetration of chemicals.	Annex B.11
3	Low-temperature storage test	—	-40 °C for 24 hrs.	— No problems were observed in terms of external appearance or physical changes, or in terms of print or communication characteristics.	Annex B.12
4	Heat cycle test	—	Cycled between -40 °C and 100 °C in 20 min. retention intervals for 200 cycles	— Warping occurred in the case of both PP and PE boards, with RF tags attached to PE boards showing numerous instances of rising. These are assumed to have affected both the IC and conductive adhesive, as well as the RF tag substrate material, resulting in communication performance degradation. — Partial peeling or delamination of RF tags also occurred in many cases.	Annex B.13
5	High-temperature storage test	IEC 60068-2-2	100 °C for 1 752 hrs.		Annex B.14

Table 1 *(continued)*

	Test item	Reference standard	Measurement conditions	Results	Refer to
6	High-temperature/ high-humidity storage test	—	85 °C at 85 % for 312 hrs.	— The PP board warped more than the PE board, and the RF tags attached to the PE board showed numerous partial peelings. — Although some RF tags showed altered communication characteristics (waveform/strength), no communication affects were observed.	Annex B.15
7	Light resistance test	—	UV-only irradiation for 72 hrs.	— Although UV irradiation showed no effects on communication performance, printing on the surfaces of all RF tags showed deterioration (embrittlement). — Fine cracks, etc., were observed in PP board materials and can be presumed to induce RF tag peeling.	Annex B.16
8	Decompression test	—	Decompression from 75,26 Kpa to 23,84 Kpa in 15 sec. and retained for 10 min.	— No problems observed in terms of external appearance or physical changes, or in terms of print or communication characteristics.	Annex B.17
9	Salt-spray test	ISO 9227	Sprayed with 35 °C saltwater for 6 hrs.	— Partial peeling was observed on some of the RF tags.	Annex B.18
10	Electrostatic discharge immunity test	IEC 61000-4-2	Three cycles of 150 pF/330 Ω (150/2 kΩ) and ±6 to 25 KV	— Some RF tags showed a loss of encoded data.	Annex B.19
11	Impact test (corner drop)	ISO 2248	Dropped once from a height of 28 cm	— No RF tags showed communication performance degradation or peeling as a result of physical stress exerted in the form of vibrations or impacts, etc., attached to the plastic RTIs.	Annex B.20
12	Impact test (horizontal shock)	—	Random vibration at 5,8 m/s^2 for 3 h		Annex B.21
13	Vibration test	ISO 13355 ISO 8318	Each side subjected to impact once at a speed of 3,6 km		Annex B.22
14	Washing resistance test	—	—	— The cleaning solution penetrated the surface substrate of some RF tags, resulting in gradual delamination of the RF tags.	Annex B.23

Annex A
(informative)

Examples of Plastic RTIs for Supply Chain

A.1 Examples of Plastic RTIs

As shown in Figures A.1 and A.2, plastic RTIs used in the supply chains range from containers, pallets, folding containers, dunnages, to more specific types. The materials are broadly divided into PP and PE materials. Plastic RTI is used as a transportation material in the automotive and distribution industries as well as in other industries. Empty plastic RTIs are stored as shown in Figure A.3.

Figure A.1 — Example of plastic returnable boxes

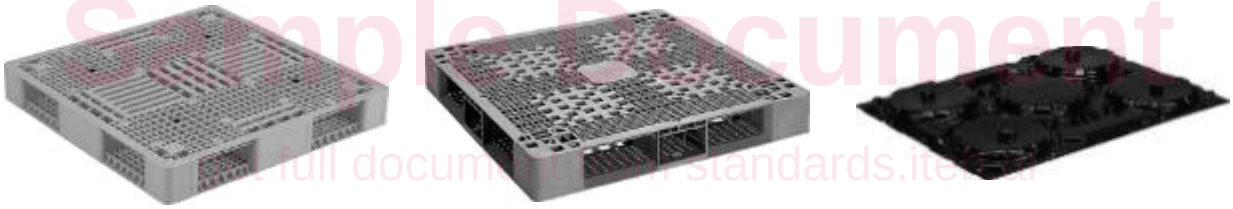


Figure A.2 — Example of plastic returnable pallets and plastic returnable dunnage

Figure A.3 — Storage of empty plastic RTIs (controlled)

Annex B
(informative)

Evaluation Tests

B.1 RF tag evaluation items

Evaluations were performed for the evaluation items shown in Table B.1, which are representative of plastic RTI problems that could occur during their use in the market.

Table B.1 — RF tag evaluation items

	Test item	Evaluation method	Description
1	Water immersion test	Evaluations performed by attaching 7 types of RF tags to plastic boards made from PE and PP materials used for plastic RTIs	RF tags were attached to plastic boards of different materials to evaluate the condition of the RF tags when changes occurred. [Examples of verification] — Conditions during plastic board expansion and contraction -> IC chip and tag antenna shifting — RF tag substrate condition — Peeling conditions caused by adhesive changes Etc.
2	Chemical resistance test		
3	Low-temperature storage test		
4	Heat cycle test		
5	High-temperature storage test		
6	High-temperature/high-humidity storage test		
7	Light resistance test		
8	Decompression test		
9	Salt-spray test		
10	Electrostatic discharge immunity test		
11	Impact test (corner drop)	Evaluations performed by attaching seven types of RF tags directly to PE and PP RTIs	RF tag conditions during impact, vibration, or washing of general-purpose RTIs were evaluated. Examples of verification are the same as those shown above.
12	Impact test (horizontal shock)		
13	Vibration test		
14	Washing resistance test		

See each item for test methods and results of each evaluation item.

B.2 RF tags used for evaluation

Seven types of general-purpose RF tags were used for evaluations and assigned numbers starting with A, B, C, D, E, FA or FB. See Table B.2 for other RF tag specifications such as substrate materials and applied surface adhesives.

The evaluations in Annex B were performed by attaching general-purpose RF tags to various types of boards.

Before performing evaluations, each RF tag was encoded with a sample number, which was printed on the surface substrate of the RF tag.

The printer ribbons used for printing were selected from among three types (a, b, c) as shown in Table B.2 based on their suitability with each label, with test printing being performed beforehand to check print quality.

Table B.2 — List of evaluated RF tag types and specifications

RF tag sample No.	Label size	Substrate material	Application surface adhesive	Manufacturer-specified sensitivity	Printer ribbon used (See Table B.3)
A	30×100	Polyethylene Terephthalate	Acrylic adhesive	4,5 m	a
B	25×25	Polypropylene	General-purpose adhesive	1,5 m	b
C	27×97	Polyethylene Terephthalate	General-purpose adhesive	7,5 m	a
D	17×73	Coated paper	General-purpose adhesive	10 m	c
E	19×44	Coated paper	General-purpose adhesive	4 m	c
FA	34×53	Polyethylene Terephthalate	Rubber adhesive	4 m	a
FB	13×83	Polyethylene Terephthalate	Rubber adhesive	7 m	a

Table B.3 — List of printer ribbons and their characteristics

Sample No.	Characteristics
a	Alcohol-resistant reinforced type
b	For polypropylene
c	Highly scratch-resistant type for paper

B.3 Type of boards used for RF tag attachment

An evaluation test was performed by attaching tag to the test board in Figure B.1 assuming plastic RTI material (PE/PP).

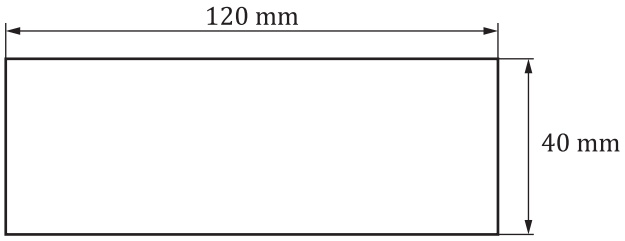
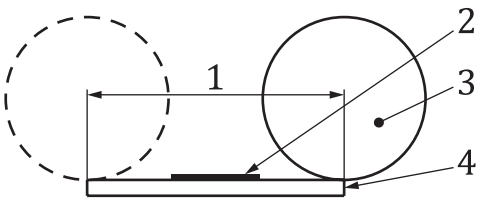


Figure B.1 — Test board size Thickness: Approx. 2 mm

B.4 RF tag attachment method

The surface of each test board was wiped with rubbing alcohol and then the RF tag was placed near the center as shown in Figure B.2.

The tag was then attached by rolling at a speed of 1 second with 3 reciprocating motions using a 2 kg roller, as shown in Figure B.3.



Key

1	three 1-second reciprocating motions
2	RF tag
3	roller (2 kg)
4	board to which tag is attached

Figure B.2 — RF tag application method

Figure B.3 — Image of RF tag attachment

For impact tests (corner drop) and washability test, RF tags were attached directly to the plastic RTI surface as shown in Figure B.4 after being wiped clean using a cloth and a commercially available 99 % ethanol solution.

Figure B.4 — Image of RF tag attachment

B.5 Quantity of each RF tag type evaluated

Evaluation sample quantities are listed in Table B.4.

Table B.4 — List of evaluation sample quantities

Test item		Application board material	Quantity of each RF tag type evaluated								Test item
			A	B	C	D	E	FA	FB	Total	
1-10	1. Water immersion test 2. Chemical resistance test 3. Low-temperature storage test 4. Heat cycle test 5. High-temperature storage test 6. High-temperature/high-humidity storage test 7. Light resistance test 8. Decompression test 9. Salt-spray test 10. Electrostatic discharge immunity test	PE	3	3	3	3	3	3	3	21	
		PP	3	3	3	3	3	3	3	21	
11~13	11. Impact test (corner drop) 12. Impact test (horizontal shock) 13. Vibration test	PE	12	12	12	12	12	12	12	84	
		PP	12	12	12	12	12	12	12	84	
14	14. Washing resistance test	PE	3	3	3	3	3	3	3	21	
		PP	3	3	3	3	3	3	3	21	

— In the tests of Test items No. 1 to No. 10, three RF tags of the same type were attached to one PE board, and each of seven kinds of tags was prepared. The same process was also carried out for the PP board.

— In the tests of Test items No. 11 to No. 13, twelve RF tags of the same type were attached to one PE RTI. The same process was also carried out for PP RTI.

— In the test of Test item No. 14, three identical PE RTIs were prepared, and seven different RF tags were attached to each. The same process was also carried out for PP RTI.

B.6 Measuring equipment

A commercially available RFID hand-held terminal was used as a measuring equipment to check communication feasibility and data retention (See Figure B.5).

BHT-1281 QULWB-CE

RFD8500

Figure B.5 — Measuring equipment