TECHNICAL REPORT

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

Part 2: Recycling and RFID tags

Technologies de l'information — Identification de radiofréquences pour la gestion d'items — Lignes directrices pour la mise en œuvre —

Partie 2: Recyclage et repères RFID

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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 24729-2, 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*

The following part is under preparation:

— *Part 3: Implementation and operation of UHF RFID interrogator systems in logistics applications*

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

Part 2: Recycling and RFID tags

1 Scope

Radio-frequency identification (RFID) is positioned to serve as a significant enabler in the recycling of various types of products; notably home appliances and electronics. At the same time various recycling streams are challenged by the possibility of RF tags being attached to recycled material, notably glass and steel.

2 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1 and ISO/IEC 19762-3 apply.

3 Symbols (and abbreviated terms)

For the purposes of this document, the symbols and abbreviated terms given in ISO/IEC 19762-1, ISO/IEC 19762-3, and the following apply.

ELV	End of Life Vehicle (European Union)
EPRP	Extended Producer Responsibility Program (Korea)
HERL	Home Electronics Recycling Law (Japan)
iNEMI	international Electronics Manufacturing Initiative
IC	Integrated Circuit
OCC	Old Corrugated Cartons
PET	Polyethylene Terephthalate
PBB	Polybrominated Biphenyls
PBDE	Polybrominated Diphenyl Ethers
ppm	parts per million
RF	Radio Frequency
RFID	Radio Frequency Identification
RoHS	Restriction Of Hazardous Substances
TID	Tag Identification
UHF	Ultra-High Frequency
WEEE	Waste Electrical and Electronic Equipment

4 Using RFID tagging to improve the environment

4.1 Use of RFID to improve waste stream recycling

The last savings that RFID tagging will provide is identifying the appropriate recycle stream for the container or item to which the RFID tag is adhered. This is especially true of containers/items that have been disposed of by consumers. The greatest problem is co-mingled consumer streams where separating corrugate, newsprint, magazines, various types of plastic, steel, and aluminium (Al) is either done manually or with expensive sensors. This use of RFID to identify and separate the different recycle streams for containers is not yet in place as of mid 2007. However AIM, the multiple waste stream trade associations and governmental environmental offices will be cooperating to define recycle stream identifiers.

4.1.1 Tracking waste with RFID

Emerging as law or regulation throughout the world are a variety of initiatives to track an item for its life and assign responsibility for its End of Life handling. These initiatives include:

- Waste Electrical and Electronic Equipment Directive in the European Union (WEEE)
- End of Life Vehicle (ELV) in the European Union
- Home Electronics Recycling Law (HERL) in Japan
- Extended Producer Responsibility Program (EPRP) in Korea

A component of all these regulations/laws is to know precisely which recycle stream an item should enter and which entity should bear the cost of end of life or recycling. Many of these expect serialization of the components with a registry of present owners and the end of life responsible entity. Thought leaders associated with all these have identified RFID tagging as a technology to execute the requirements of the regulations/laws in the most efficient fashion. However as of mid 2007, only isolated pilots are being run and no additions to regulations or trade association guidelines requiring RFID identity have occurred.

4.1.2 Recycle process mark

A data element that a license plate RFID tag will point to is the recycle stream the container or item is to follow. AIM will petition ISO to incorporate and define a compact location in the memory of each RFID tag to point to the appropriate recycle stream for the tagged package or product. In addition to a human readable mark, the RFID tag will provide a Recycle Process Mark in at least one of the following ways:

- a field in the tag memory that identifies the recycle stream
- a data element in the publicly available central data base that identifies the recycle stream

Annex A provides a list of European recycle streams.

4.2 Recycle process automation

It is assumed that recyclers will install automated processes that will singulate the recycled containers so they may be reliably identified with the RFID tags. Once identified the container to be recycled will be routed to the correct recycle stream where the RFID tag and container will be handled as described by the trade association guidelines

5 Recycling of RF tags

5.1 General

Consideration of Recycling and RFID in this document is split between passive tags and active tags. Generally passive tags reflect and modulate an interrogator-generated signal and are powered externally by harvesting energy from the field created by an interrogator in the vicinity of the passive tag. Active tags generate a radio signal and usually carry some source of energy that allows operation without the presence of an external power source. Most frequently the on-board source of energy is a chemistry-based battery.

5.2 Passive tags

5.2.1 Overview

Passive tag technology typically does not use an internal source of power but usually relies on power provided by the interrogator. They are simple in construction and lower in cost when compared to active tag technology. Annex B shows the constituent makeup of a typical UHF passive tag.

The major constituents in RFID tags are:

PET – One form of RFID tags uses copper (Cu) or aluminium etched from a PET (polyethylene terephthalate) substrate. The substrate also acts as a high tensile carrier for tag making and application. To dispose of PET, it can be incinerated (produces only CO_2 and H_2O) or handled as basic landfill waste.

Al – The third most plentiful element in the world is relatively benign and has a substantial recycling infrastructure in place in the developed world. PET substrate with aluminium can be incinerated and the Al can be collected to be used as recycled raw material for other purposes. For example one plant in Varkaus, Finland (Corenso United) incinerates Al containing juice/milk cans and Al is collected separately. Aluminium and Al containing material can be normally handled also as landfill waste.

Cu – Pound for pound, copper is much more expensive than Aluminium with recycle infrastructure in place where copper makes up a larger percent of the recycle waste than it appears in RFID tags. Copper is a bit more problematic in the presence of other elements that are reclaimed by furnaces. Copper tends to impact these other furnace process if available in a substantial quantity. PET substrate material containing copper can be incinerated in a special incineration oven, however it is normally not recommended due to the very high incineration temperatures and special ovens needed. Cu can be handled as common landfill waste in many countries, but not in all.

Ag - The most expensive conductor used in RFID tags, normally as very small particles suspended in a resin to from a silver (Ag) based ink for antenna printing. Unlike Al and Cu which exhibit a connected crystalline structure in RFID tags and a subsequent tendency to remain intact in recycle processes, silver particles remain particles. Normally silver based inks are printed on cellulose substrates (labels). During recycling where the cellulose loses its structurally integrity, the silver particles are distributed through out the slurry in a non-recoverable form. Historically, incineration of silver containing carrier has been avoided.

Adhesive - Adhesives generally used to laminate RFID tags can be incinerated or handled as landfill waste with no change in processing.

5.2.2 Passive RFID tags and presently recycled materials

5.2.2.1 Use of Passive RFID tags

Passive RFID tags may be used to identify a whole host of items and containers of items. Generally the requirement of most RFID tagging mandates is to tag the package, shipping container, or pallet for multiple items vs. tagging the items. Consequently RFID tags will predominantly proceed to either the end disposal or reuse of the package, shipping container or pallet. One of the usual business cases for RFID tagging is high confidence identification throughout the supply chain of what is tagged. Consequently, RFID tags are

generally adhered or integrated to what is tagged in a very aggressive way. Many applications prefer the RFID tag be damaged or tamper evident if removed. That is, RFID tags are designed to be hard to remove from what they identify.

In addition, a growing number of assembled items will have their subassemblies tagged. That is an assembled item, like a plane or a printer will have subassemblies tagged. Consequently, in these assemblies there could be multiple RFID tags. The business case for tagging subassemblies may be recall, warranty validation, anti-counterfeiting, etc. These business cases also require very aggressive adherence to the subassembly that is tagged to insure the business case justification is not jeopardized.

5.2.2.1.1 Minimizing the solid waste environmental impact of tags

Mandated RFID tagging by major retail and government entities create a situation where massive amounts of RFID tags will be entering the waste stream of the container or item to which the tag is attached. This is especially true for corrugate and plastic containers, and to a lesser extent for steel and aluminium containers. The highly suggested approach to minimize the impact of the introduction of large quantities of RFID tags is cooperation with the trade association already defining procedures to recycle the package waste stream.

Although a subtle point, a recycle stream is defined by the major constituent that emerges as the recycled raw material. Consequently, the impact RFID tags have on recycling is measured by both the change in purity in the emerging raw material and the change in cost to achieve a level of purity.

5.2.2.1.2 Trade association waste stream guidelines

For each of the waste streams indicated the following trade association has been contacted

Table 1 — Waste streams and trade associations

Waste Stream	Trade Association	Annex
Corrugate and Fibre Board	Fibre Box Association/National Council for Air and Stream Improvement	D
	Confederation of European Paper Industries	E
Plastic	Society of Plastics Engineers	F
	Society of Plastics Industries	G
Glass	Glass Packaging Institute	H
Steel	Steel Recycling Institute	I
Aluminium	Aluminum Association	J

Basically contact is made with the trade association indicating the volume and constituents of RFID tags that will be seen in their waste stream. This leads to a 6-step program on the part of the trade association and the RFID industry:

1. Theoretical assessment of whether the influx of RFID will affect present recycling processes
2. Pilot testing to verify that the present processes are sufficient or that proposed process changes are sufficient with RFID present.
3. Draft guidelines to be used by the RFID industry and the waste stream recycle industry. Submit the guidelines to a knowledgeable 3rd party such as a university knowledgeable in the particular waste stream
4. Submit the 3rd Party reviewed guidelines to the appropriate national or regional environmental agency for approval

5. Issuance of guidelines to the Trade Association members and the RFID tagging community that maximize the benefit of RFID and minimize any negatives on Recycling.
6. Have either RFID trade association, AIM Global or EPCglobal, etc. certify that particular RFID tags meet the guidelines. At this date, no trade association has instituted certification process relative to Recycling and RFID tags.

The assessment by each trade association is based on submitted tag constituents by RFID tag manufacturers. These constituents fall into the following two categories:

1. Connected crystalline metal antenna most on plastic substrates
2. Silver based Inks on cellulose substrates.

The specific constituent ranges of passive tags are provided in Annex A.

5.2.2.1.3 Tag antenna guideline for corrugate

Existing data indicates connected crystalline tags using Al and Cu on corrugate may proceed. Between CU and Al, Al is preferred because Cu can damage many incinerators. Companies using printed silver based antenna should be aware that 85 % of the silver continues to be bound in the recycled cellulose. Even though this guide establishes the acceptability of crystalline connected tags for corrugate, companies should be continuously following local regulations relative to allowable levels of materials listed on Prohibited and Allowable Substances list (Annex P) to insure this guideline does not become obsolete locally.

5.2.2.1.4 Adhered and integral tagging

For many reasons, the location of an RFID tag will need to be made obvious. Most obvious will be human recognizable locator, for example the AIM Global RFID Emblem. Having the location obvious may be required in order to focus on the appropriate read location or accomplish the next stage of the tag's or tagged component's life cycle. It may also be used to accomplish a tag “kill”. For RFID tags that are embedded under one or more layers of linerboard, an AIM Global RFID Emblem is preferably applied to the exterior of the carton in close proximity to the buried tag.

The vast majority of RFID tags will be adhered to the container or item they identify. Adherence means adhesive or fasteners were used for attachment. When adhered there is usually a process for removal whether it be chemical, heat, solvent, grinding, etc. As stated elsewhere, the business cases justifying RFID normally require removal processes to be difficult for individuals to execute. However, industrial or institutional approaches can be made quite efficient.

As a consequence, the entity supplying the product that is tagged must select a tag designed to meet guidelines based on existing recycle stream in which the RFID tag will be found at end of life. The stream will be the one associated with the item or package tagged. Knowing that a selected RFID tag is designed to be acceptable in a recycle stream, the supplier of tagged product will make this recycle stream publicly available. For example, where the RFID tag is a license plate pointing to a database, an entry in the database is the recycle stream. For RFID tags that carry all required data in its memory, some portion of the memory should identify the recycle stream.

In certain implementations, the RFID tag will be integral to the container or item. For example, reusable plastic container may have RFID tags integrally molded or inserted into the container or item. When integral, both the tag and container/item may likely be unusable after a tag is removed. Examples of items with integrated tags are computers, printers, or other consumer electronics.

5.2.2.1.5 Decommissioning Tags

Related to recycling are the potential options of decommissioning tags and retirement. Each industry that uses RFID across multiple owner interfaces may have work processes to decommission/retire/re-commission RFID tags. Decommissioning is a process to notify all information owners that additional information will not be created to be associated with a particular RFID tag identity. Frequently retirement and decommissioning occur in close chronological order to item or package disposal. Each industry must define if decommissioning means

physical destruction or electronic killing. In general, recyclers such as 'four vector' re-pulping mills will mechanically destroy RFID tags and dispose of them according to clause 6.2.4 without notifying previous information owners.

If RFID tags are reused, a central registry will be needed to rationalize the reappearance of the IC's TID with new user memory contents.

5.2.2.1.6 Disposing and replacement of bad tags

During the course of tag creation and material movement, RFID tags may become prematurely non-functional. It is assumed some subsequent owners of the product will replace non-functional tags with functional ones. This includes inlet and label manufacture, printing, attachment, product handling and delivery. Each industry will decide if the replaced tag assumes the same identity as the tag originally with the identity or if the replaced tag will assume a new and unique identity or if the identity information associated with the backup, such as barcode, is sufficient

When an RFID tag is replaced, it must be removed, because adhering a new RFID tag over the face of the non-functional tag will likely result in poor RF functionality of the new tag. The non-functional tag must be removed and disposed of. The tag replacing entity must then consider the non-functional tags as waste and follow the procedures outlined in clause 6.2.4.

It is the responsibility of the tag replacing entity to verify that RFID tags that they add to containers has constituents that fall within applicable trade association waste stream guidelines

5.2.2.1.7 Pharma example

In emerging requirements in the pharmaceutical industry, every unit of sale is to be tagged in a serialized fashion from manufacture to pharmacy. However the value, both financially and clinically, is so high for each unit of sale that units with bad tags must, with minimum intervention, continue in the supply chain when an RFID tag fails. Consequently, sale units will likely carry a compact barcode backup. Depending on how close to the pharmacy in the supply chain and the cost of intervention at subsequent steps, the RFID tag will likely be replaced.

5.2.2.1.8 New tag designs

It is the responsibility of tag manufacturers to submit to the appropriate trade association for each recycle stream new tag designs that have different components or components beyond the listed ranges for re-assessment. Trade associations are not required to reassess new tag designs and likely will require incentives to consider new tag designs.

5.2.2.1.9 New or expanded tagging mandates

It is the responsibility of the initiator of new tagging initiatives to re-submit to the appropriate trade association for assessment a change that will change the ppm loading of RFID tags to the main recycle stream. For example if retailers move from case and pallet tagging to item level tagging, it will be the retailers' responsibility to work with waste stream trade associations to assure that the added loading level of RFID tags is inconsequential or if new recycling processes must be developed.

5.2.3 Recycling

5.2.3.1 Returnable assets

RFID tags can be used multiple times or multiple turns if placed on returnable assets. Returnable assets such as pallets, crates, roll cages, etc. will begin to carry one or more permanently attached RFID tags that convey both the asset identity and the temporary contents in/on the asset. The asset identity will be permanent to allow tracking. The content tag will be password changeable. Rewritable RFID tagged returnable assets provide many turns, perhaps a few hundred, before the asset and tags are retired and recycled. This large potential reuse of the asset and its RFID tag much reduce the waste stream burden.

5.2.3.2 Returnable tags – identity re-registration

An emerging industry is reusing tags from disposable containers so the tags will be reused, but the container will be destroyed or recycled. For example, corrugate case-level tagging using a durable RFID tag that is capable of being reused several times. Preferred processes for recovering such tags are integrated into specially equipped paper mills that re-pulp old corrugated cartons (OCC). Such mills are retrofitted to create a fifth vector: used tags. Doing so eliminates contamination of the other four vectors namely: solids, liquids, screens, and product. Reuse of RFID tags will in general offer RFID tagging at a lower cost per turn. The key to creating a Used RFID tag market is using rewriteable tags where the content can be rewritten, that is reused tag memory CANNOT be permanently locked.

5.2.4 Disposal of passive tags as waste

At end of life, a passive tag can be disposed of in several ways:

- thermal recycling with energy and constituent recovery, land-filling ash remains
- mechanical/chemical separation for constituent reuse
- direct landfill

Local economics and regulations will determine which of the above processes will be used. Studies by the corrugate industry indicate incineration with subsequent ash landfill or direct landfill are acceptable for final disposal of RFID tags collected in the first filtration of recycled corrugate.

5.2.5 Other regulatory considerations

Environmental Regulatory activity throughout the world may impact the proliferation of passive RFID tags. The regulations have the potential to impact RFID tagging significantly both positively and negatively. Based on interpretation, these regulations could limit RFID tag use, promote RFID tag use, or alter recycling processing.

As well these regulations may significantly drive the use of RFID tags to track and identify other items that come under these regulations. RFID may be required to validate final disposal of other items as defined by these regulations.

The most significant regulatory activities as of mid 2007 that are pending are:

- Waste Electrical and Electronic Equipment Directive in the European Union (WEEE) (Annex K)
- Restriction of Hazardous Substances (addendum to WEEE) (RoHS) (Annex L)
- End of Life Vehicle (ELV) in the European Union (Annex M)
- Home Electronics Recycling Law (HERL) in Japan (Annex N)
- Extended Producer Responsibility Program (EPRP) in Korea (Annex O)

Status of the above as of mid 2007:

5.2.5.1 WEEE (all aspects to be enforced as of 1 July 2006)

A final determination as to whether passive tags are eWaste has not been made, but the leaning is the tagged item determines if a passive tag needs consideration under WEEE, that is, on items that are not eWaste, the passive tag is not eWaste, but if the item is eWaste, handling the passive tag must be considered. Where passive RFID tags are the sole or primary constituents of waste, no determination has been made. Readers and printers have been considered under WEEE.

5.2.5.2 RoHS (all aspects to be enforced as of 1 July 2006)

As originally proposed last year, of the six substances banned by RoHS, lead, mercury, hexavalent chromium, PBBs (Polybrominated Biphenyls) and PBDEs (Polybrominated Diphenyl Ethers) will now be allowed in "homogenous materials" up to 0.1 % by weight. Cadmium will be allowed up to 0.01 % by weight. Readers and printers have to consider RoHS in selection of manufacturing approaches.

5.2.5.3 ELV, HERL, EPRP

Several articles and presentations by organizations like International Electronics Manufacturing Initiative (iNEMI) suggest the use of unique part numbers and RFID to mechanize the execution of these regulations, but to date neither trade association nor regulators have chosen an RFID aided execution.

5.3 Active tags

5.3.1 General

Active tags differ from passive in that they are usually more complex and normally contain an internal power source (such as a battery). Annex C shows the makeup of a typical UHF active tag (including battery)

5.3.2 Presently recycled material

Unlike passive tags, active RFID tags are used to track higher value assets and to provide a greater stand-off distance and/or tag functionality (such as sensors). These tags usually cost a great deal more than passive tags and are more complicated in design and operation. Most active tags, like passive tags react to an RF field, with the active tag itself "turning on" (switching from a standby mode to an active mode), upon receipt of a command from an RFID reader. However, some active tags are "turned on" either periodically signal (or pulse) or the tag reacts to an external action that results in transmission (received transmission, change in sensor data, or activation of a switch).

Battery-assisted passive tags, which are sometimes confused with active tags, are usually passive tags that have been enhanced with a battery-powered circuit. This enhancement usually involves a powered accessory, such as sensors or memory, and/or a power boost to the return RF signal. Battery-assisted passive tags cannot generate an RF signal without entering the RF field of a passive interrogator just like a standard passive tag.

By their very nature, active tags are generally attached to an object in such a way that they can be removed and replaced easily. The use of a battery to power these tags usually makes this a requirement. The tag will have to be removed periodically to change the battery or, if the battery is non-replaceable, to replace the entire tag.

Except in rare instances using highly specialized applications, active tags will not be recycled with the object it is tracking or the objects container. In most instances, the active tag will be attached to a reusable transport container. As the container is reused, the tag is reused as well. When the container reaches its end of life, the tag can be removed and reused.

5.3.2.1 Active tags separation

When tracking is no longer required for an item, the tag is removed and deactivated (if possible). At that time, the tag can be reused to track another asset or container.

If a tag enters the waste stream, it should be treated as any other electronic component such as a two-way radio or other battery powered devices.

5.3.2.2 Recycling batteries

It is important to use proper recycling practices when dealing with tag batteries. Most tags use Lithium (metal) batteries which contain no toxic metals; however, there is the possibility of fire if metallic lithium is exposed to

moisture while the cells are corroding. For proper disposal, these batteries must be fully discharged in order to consume all metallic lithium content.

Since lithium batteries are not rechargeable, this is no reuse. There are currently a number of companies that specialize in the recycling of material in lithium batteries. Local regulation or practices for lithium battery disposal are to be followed.

5.3.3 Reuse of active tags

By their very nature, active tags are reusable to track other assets. The life of an active tag is only limited by the life of the battery. In cases where the battery can be replaced, the active tags life can be greatly extended beyond the battery life. In these cases, the tag will usually become technically obsolete before it no longer functional/useful.

5.3.3.1 Reuse infrastructure

Since active tags are primarily used in closed systems, it is up to the user to devise a method by which the tag is reused. In cases where the container is reusable, the tag can be made a permanent part of the container and reused with the container. When the time comes to dispose of the container, the tag can be removed and reused or disposed of separately.

The active tag is treated as a computer component when it comes to disposal and recycling of the material.

5.3.3.2 Identity re-registration

Most active tags contain a non-changeable tag id and some memory. The memory is re-writable and allows the tag to be “re-commissioned” for another task. Within a database, it is usually a simple task to associate the tag id with a new asset.

5.3.3.3 Unaccounted for active tags

A large number of active tags can be left on containers, fall off or be removed during transport. The tracking system can be used to identify some of these tags. It can also be used to find containers that have been lost in transit.

Annex A
(informative)

Recycle streams

A.1 No. L 50/28 Journal of European Communities 20.2.97 (97/129/EC)

Annex B
(informative)

Chemical make-up of a typical passive RF tag

Table B.1 — Passive tag constituent parts

Tag size		76,2 mm x 76,2 mm	15 mm x 97 mm	15 mm x 148 mm	
Breakdown of component	**Material**	**Substance Mass (mg)**	**Substance Mass (mg)**	**Substance Mass (mg)**	**Specific Gravity**
Face material	PP	270	65	100	
	Paper	525	130	200	
Adhesive	Acrylate	115	30	45	
IC	Silicon	0.5	0.5	0.5	
ACP	Epoxy based material	0.8	0.8	0.8	
ACP Metal	Nickel	0.1	0.1	0.1	
Adhesive	Polyurethane	40	10	15	
Antenna	Copper	340	105	140	8.9
	Aluminium	50	15	20	2.7
(printed)	Silver		10.9		10.5
(printed)	Bonding Agent		4.6		
Substrate	PET	410	100	155	
Adhesive	Acrylate	155	40	60	

Annex C
(informative)

Chemical make-up of a typical active RF tag

Table C.1 — Active tag constituent parts

Part	Vol in In^3	Major component	Secondary component
resistors	0.001843412	Alumina Porcelain	
capacitors	0.001660829	Calcium Magnesium Titanate	
diodes	0.001092787	Silica + Carbon Black	iron
transistors	0.002404131	Silica + Carbon Black	iron
ICs	0.025527186	Silica + Carbon Black	copper
base	0.881186306	Lexan EXL 9330	
cover	1.658021602	Lexan EXL 9330	
inductors	0.00659059	ceramic	copper
ceramic filters	0.005126015	ceramic	copper
crystals	0.003661439	Silicon Dioxide	Steel
labels	0.011038018	Polyester	
headers	0.000317442	Phosphor Bronze	plastic
beeper	0.053479893	Noryl	copper
pins	0.011540032	Brass Alloy 360	
wire	0.023494233	copper	teflon
battery contact	0.008053492	Phosphor Bronze	
heat shrink	0.002990175	Polyolefin	
epoxy	0.009153597	Ethyl cyanoacrylate	
foam tape	0.029730884	Acrylic foam	
Copper Tape	0.162323793	copper	
plug	0.061023982	Ethylene Propylene	
pwbs	0.292182828	FR4 fiberglass	copper
Solder Paste	0.008756941	Tin	
	0.003234271	Lead	
Batteries	0.676018795		stainless steel
	0.03380094	Lithium	
	0.310968646	Thionyl Chloride	
	0.03380094	Aluminum Chloride	
	0.027040752	Carbon	

Annex D
(informative)

Fibre Box Association National Council for Air and Streams Improvement

Members only report, call +01 847 364 9600

“Fate of Copper and Silver from RFID Labels During Recycling of OCC and Potential Environmental and Product Implications”

Annex E
(informative)

Confederation of European Paper Industries

http://www.cepi.org

File version 1.4 – 14749A

Annex F
(informative)

Society of Plastic Engineers

http://www.4spe.org

Annex G
(informative)

Society of Plastic Industries

http://www.socplas.org

Annex H
(informative)

Glass Packaging Institute

http://www.gpi.org/info/rfid

Annex I
(informative)

Steel Recycling Institute

http://www.recycle-steel.org

http://www.steel.org

Annex J
(informative)

Aluminum Association

http://www.aluminum.org

Annex K
(informative)

Institute of Scrap Recycling Industries

http://www.isri.org

Annex L
(informative)

Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC of the European Parliament

http://www.eu.int/eur-lex/pri/en/oj/dat/2003/l_037/l_03720030213en00240038.pdf

http://europa.eu.int/comm/environment/waste/weee_index.htm

Annex M
(informative)

Restriction Of Hazardous Substances (RoHS) Directive 2002/95/EC of the European Parliament

http://www.eu.int/eur-lex/pri/en/oj/dat/2003/l_037/l_03720030213en00190023.pdf

http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=32002L0095&model=guichett

Annex N
(informative)

End of Live Vehicle (ELV)

http://europa.eu.int/comm/environment/waste/elv_index.htm