RFID based monitoring the cold chain

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Cold Chain Management
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1. Department of Logistics (UniDo)
2. Basics of Radio Frequency Identification (RFID)
3. Requirements of a cold chain integrity concept
4. The concept of sensor based RFID (ISRFID)
5. Results from Research Projekt „Trakü“
Department of Logistics (UniDo)

- Retail and transportation Logistics
- Packaging Logistics
- Waste management Logistics

Research and Development on behalf of German Federal and Federal State Authorities, EU, DfG, Organisations, accredited laboratory of der BVL, DVEU and the GVB

Logistic Identification Laboratory
- Demonstration and test center of various RFID-Systems
- Ability to test and prove any RFID technology and influence factors

Test Laboratory for specific mechanical and technological testing packaging and packing materials according to DIN EN ISO/IEC 17025

Test center for packaging of dangerous goods on behalf of the German Federal Institute for Materials Research and Testing Berlin (BAM)

Electronic surveillance system testing laboratory according to VDI directives VDI4470, VDI4471, VDI4473, VDI4475
**Working / Environmental Conditions**

- Thermal Resistance / stress (climate-testing laboratory)
- Resistance against climate impacts
- Mechanical load (static / dynamic)
- Resistance against chemical substances

**Performance**

- Mounting Place / Substrate (metall, Liquids, etc.)
- Penetration through material
- Ability to read transponder in a Bulk
- Read ranges
- Detection area of different antenna field patterns

**Electromagnetic Properties**

- Electrical and magnetic field strengths
- Evaluation of quality factor from inductive coupled RFID-Systems
- Bandwidth and resonance frequency
- Minimal magnetic flux density at different frequencies for reading and writing

Department of Logistics (UniDo) - LogIDLab
RFID: **Radio Frequency Identification**
(System to communicate between transponder and an interrogator)
Basics of RFID

- **internal Computer Application**
- **interrogator and antenna**
- **transponder or tag**

**Local interface**

**Air interface**

- **antenna/inductive reactance**
- **Housing**
- **microchip**

Data processing (backend)

Magnetic field (inductive coupling) or electromagnetic waves (backscatter-coupling)
Comparison of different detection pattern of UHF transponders

Transponder antenna (observer): 72mm x 72mm

Transponder antenna (observer): 97mm x 15mm

red: “horizontal layer"
blue: “vertical layer”

antenna detection pattern by changing the location of the transponder with respect to the reader antenna, 2 Watt (ERP), EPC 1.19, tests in LogIDLab®
<table>
<thead>
<tr>
<th>Working frequencies</th>
<th>100-135 kHz</th>
<th>13.56 MHz</th>
<th>868/915 MHz</th>
<th>2.45 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function principle</td>
<td>Inductive coupling</td>
<td>Backscatter coupling or electromagnetic waves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power supply</td>
<td>Passive</td>
<td>Passive and semi-active (battery for sensors)</td>
<td></td>
<td>Passive and active</td>
</tr>
<tr>
<td>Data saving</td>
<td>Read-only und read/write (up to 2 kBit memory capacity)</td>
<td>Nearly only read/write (up to 2 kBit memory capacity)</td>
<td></td>
<td>Read-only und read/write (up to 256 kBit memory capacity for active systems)</td>
</tr>
<tr>
<td>Range</td>
<td>Less than 1,0 m</td>
<td>Up to 1,7 m active (ca. 8-60 cm)</td>
<td></td>
<td>Up to 6,0 m for passive systems; Up to 100 m for active systems</td>
</tr>
<tr>
<td>Influence of metal</td>
<td>Weakening of magnetic field, disturbance of the resonance frequency, a ferrite layer or a ferrit core can lower metal influences</td>
<td></td>
<td></td>
<td>Reflections on metal surface; modification necessary for direct application of the antenna on a metal surface</td>
</tr>
<tr>
<td>Influence of liquids</td>
<td>Low</td>
<td>High</td>
<td>Very High</td>
<td></td>
</tr>
<tr>
<td>Bulk ability</td>
<td>Possible, but rarely realized</td>
<td>Possible (up to 100 pcs.)</td>
<td>Possible (up to 500 pcs.)</td>
<td>Possible (up to 500 pcs.)</td>
</tr>
<tr>
<td>Life span</td>
<td>EEPROM (passive read/write System) from 10,000 bis 100,000 write cycles, SRAM (active read/write System) nearly infinite amount of read/write cycles, active and semi-active Systems are depending on their batteries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data transmission rate</td>
<td>Low (approx. 4 KBit/s)</td>
<td>6.62 KBit/s (ISO 15693) 106 KBit/s (ISO 14443)</td>
<td>Very high (up to 848 KBit/s, ISO 18000-6) IQ-32T (115.2 KBit/s)</td>
<td></td>
</tr>
<tr>
<td>Designs</td>
<td>Glass capsule, Stick, Nails</td>
<td>Label, Card</td>
<td></td>
<td>Label, Plastic Housing (IP 67)</td>
</tr>
<tr>
<td>Approx. price [€]</td>
<td>0.50 - 1.00 passiv</td>
<td>0.40 - 0.70 passiv, 8.00 with sensor</td>
<td>0.40 - 0.70 passiv 60.00 with sensor</td>
<td>30.00 bis 50.00 aktiv</td>
</tr>
</tbody>
</table>

Technical Restrictions
overview verified by LogIDLab®

Interrogator with antenna - ISO/IEC 14443, ISO/IEC 15693

Transponder - ISO/IEC 14443, ISO/IEC 15693

Air Interface - ISO/IEC 18000

Data format - ISO/IEC 15963


Test methods

Class 1 Generation 2 UHF Air Interface Protocol Standard

EPC Tag Data Standard

Standards and Regulations RFID

FLog
Requirements of a cold chain integrity concept according to DIN ISO 22000
**Informations in a database**

„Data-on-network“

- Easy, cost-efficient transponder
- Write-once-read-many transponder
- Clear and unambiguous product identification
- Uniform standard
- Central data storage

**Informations in a transponder**

„Data-on-tag“

- Intelligent, but expensive transponders
- Read-write transponder
- Large quantity of Information
- Additional features
- Distributed data storage

**Information across the process chain**

**Control and Information**

- Identification number (EPC)
- Instruction sheet
- Testing and supervisioning mark
- Source node
- Destination node
- Number of items
- Transport number

**The concept of RFID based monitoring (ISRFID) – data consolidation**
Types of transponder: UHF-Transponder

Transponder (i-Q32T SL/EU):

- Aktive transponder (with own batterie; life span up to six years)
- Read range up to approx. 100 m
- Working frequency: 868 MHz / 915 MHz
- Protection class: IP 65
- Memory capacity up to 13,312 temperature-timestamp values
- Measurement interval is arbitrary selectable
- Temperature bandwith: -40°C up to +70°C
- Measurement accuracy: 0.5 °K
- A light-emitting diode (LED) can visualize different transponder states
- price: 69,80 € (1-500) … 52,35 € (> 50,000 Stk.) (19.09.05, Baumer Ident)
- Dimensions: 131 × 28 × 21 mm (l × w × h)
Types of transponder: HF-Transponder

**TETA – Transponder (TempSens®):**

- semi-aktive transponder (batterie to support memory)
- Read range up to ca. 1 m
- Working frequency : 13.56 MHz
- Measurement accuracy: 0.5 °K
- Temperature bandwith : -15°C up to +50°C
- Measurement interval :10 sekunds up to 16 hours
- Memory capacity up to 64 time-temperature values
- price: 21,24 € (1-10)...6,30 € (100000) (09.06.2005, KSW microtec)
- Dimensions: 86 x 54 x 1,35 mm (l x w x h)
- Weight : 5,6 g.
- Data transmision speed: defined in DIN ISO 15693-3
- 6 Byte for Protection (access protection)

The concept of sensor based RFID (ISRFID)
The procedure of the e-pedigree „Data–on-Tag“ method

Sample: Cold chain

Production
Manufacturer

Transport

stocking
Producer

Transport

stocking
wholesaler

Transport

Retailer

Pedigree
Shipping number
Shelf-life time
Payload (time/sensor data)
Manufacturer details

Pedigree
Shipping number
Shelf-life time
Payload (time/sensor data)
Manufacturer details

Pedigree
Shipping number
Shelf-life time
Payload (time/sensor data)
Manufacturer details

Pedigree
Shipping number
Shelf-life time
Payload (time/sensor data)
Manufacturer details

The concept of sensor based RFID (ISRFID)
The procedure of the „Data–on-Network“ method

**Sample: cold chain**

- **Station**
  - Production Manufacturer
  - Transport
  - stocking Producer
  - Transport
  - stocking wholesaler
  - Transport
  - Retailer

- **end2end-connection**

- **Station**

- **source- / destination- node**

- data container with quality-data. (time/temp.)

- quality level

- up to next node

- timestamp

- **order-ID**

- pick-ID

- contract-ID

- **central DB**

- **cold-chain-management (access processing, Stations management, data encapsulation)**

- **product information**: shipping ID, EPC, UID, packaging-ID, MTV-ID, etc.

- **secure network**

- **The concept of sensor based RFID (ISRFID)**
The concept of sensor based RFID (ISRFID)
### Results from Pilot Projects (Traku)

#### Traku User Interface

<table>
<thead>
<tr>
<th>Auftrag</th>
<th>223</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nummer Item</td>
<td></td>
</tr>
<tr>
<td>Nummer Gebäude</td>
<td></td>
</tr>
<tr>
<td>Nummer Versandort</td>
<td>31401407/6534/74/36103</td>
</tr>
<tr>
<td>Produktklasse</td>
<td>Bürger</td>
</tr>
<tr>
<td>Temperaturklasse</td>
<td>NEU</td>
</tr>
<tr>
<td>Min Temperatur (Grad)</td>
<td>-30.0</td>
</tr>
<tr>
<td>Max Temperatur (Grad)</td>
<td>20.0</td>
</tr>
<tr>
<td>Verifier</td>
<td>0</td>
</tr>
<tr>
<td>Nachfilter</td>
<td>0</td>
</tr>
<tr>
<td>Ziel Ort</td>
<td>Warenausgang 19-7</td>
</tr>
<tr>
<td>Menge</td>
<td>33</td>
</tr>
<tr>
<td>Herstelldatum</td>
<td>09.12.06</td>
</tr>
<tr>
<td>Mindesthaltbarkeitsdatum</td>
<td>08.04.06</td>
</tr>
<tr>
<td>Lüfter Intervall (min)</td>
<td>1</td>
</tr>
<tr>
<td>Transponder ID</td>
<td>UBEDIPIE</td>
</tr>
</tbody>
</table>

**Scan Tags**

![Image](image_url)
stock temperatur (production) < -18 °C
goods issue inspection (production)
Results from Pilot Projects (Trakü)
production - goods issue inspection (temperature and histogram)

Results from Pilot Projects (Trakü)
goods issue (production) - goods receipt inspection (stock) - transportation
goods issue (production) - goods receipt inspection (stocking) - transportation

Results from Pilot Projects (Trakü)
goods issue (stock) - delivery (restaurant) - transportation
Zeit [h]  | Temperatur [°C]  
---|---
0 | -24
5.3 | -21
10.6 | -18
15.9 | -15
21.3 | -12
26.6 | -9

TK–Lager / Lkw Fahrt / Belieferung

Häufigkeitsverteilung der Temperaturen

Results from Pilot Projects (Trakü)
RFID based monitoring the complete cold chain

Results from Pilot Projects (Trakü)
Conclusion:

- The RFID Technology has enormous potential to cope with the problems of automatical identification and context based sensor information across the supply chain.

- Businesses can speed up the processes of product identification.

- With RFID the shipment can be confirmed faster.

- No more time is needed for opening the packaging for visual confirmation.

- Even if there are some economical advantage (bulk ability, reading range) it is important not forget that equipping product, pallets or loading units with RFID transponder is restricted by the physics boundary conditions. Therefore on material mounted transponders could lead to different reading ranges.

Results from Pilot Projects (Trakü)
Thank you for your attention!