

PACKAGING: HOW IT IMPACTS RFID INTEGRATION

By Dr. Robb Clarke
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Advancing Knowledge.
Transforming Lives.



THE SCHOOL OF
PACKAGING
MICHIGAN STATE
UNIVERSITY

Why Packaging?

- **As Throckmorton P. Ruddygore III once observed, “Packaging is the Center of the Universe”.**
- **It is a ground level, hands-on approach as opposed to many 30,000 foot views of RFID.**
- **Let me now explain WHY this is so.**

Packaging: What Is It?

- **Different Levels (1°, 2°, 3°, through to unitized pallet loads or cargo containers)**
- **Different Requirements for Different Industries (Consumer, Industrial, Military, Medical/Pharmaceuticals)**
- **All with an eye toward:**
 - **Cost (versus price),**
 - **Environmental Issues,**
 - **Ease of Handling, Shipping, Storing, etc**
 - **And many more...**

Functions of Packaging

❖ Four main functions:

- **Containment** (no)
- **Convenience/Utility** (maybe)
- **Communication** (yes)
- **Protection** (yes)

The Impact of This...

- **Everything has to be packaged**
- **All companies and industries use it.**
- **It should withstand all the rigors of Distribution, Manual and Mechanical Handlings, Warehousing and Storage, not create any problems, and give the ultimate user a sense of 'value'.**

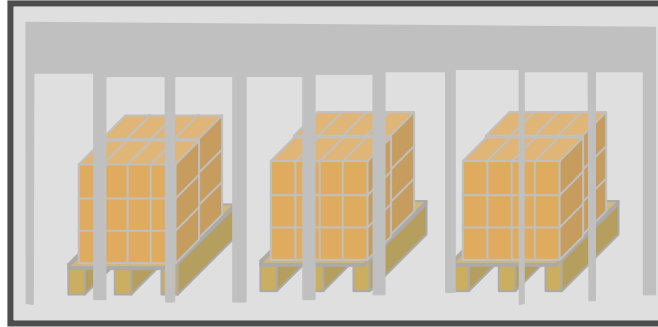
SoP AutoID Laboratory

- **We focus on RFID APPLICATIONS in the Supply Chain, particularly warehousing, inventory control and order verification.**
- **Goal is to develop the “Perfect Purchase Order”.**

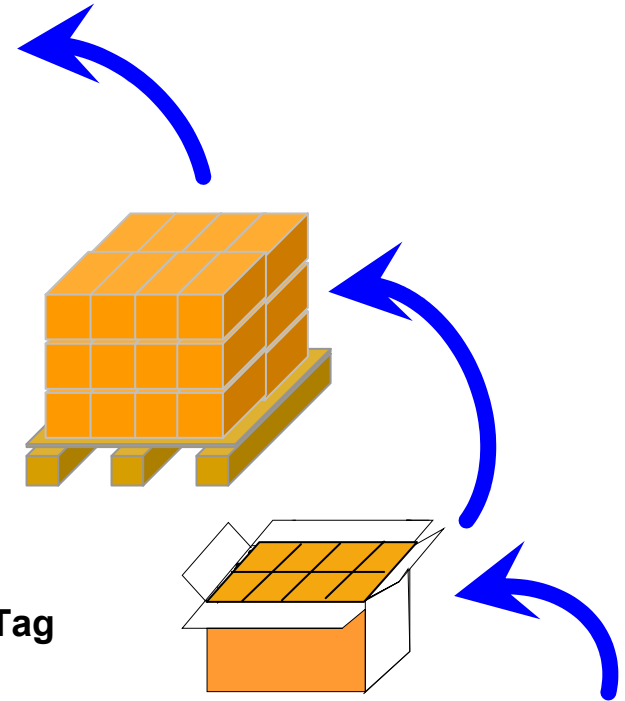
Complementary Active and

Passive RFID

Active Container Tag
associated to a...

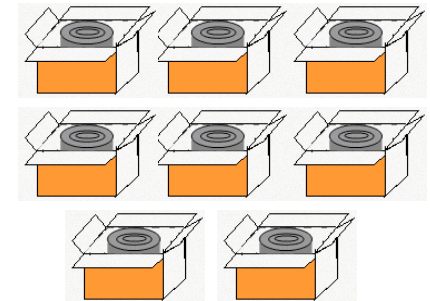


Passive Pallet Tag
associated to a...

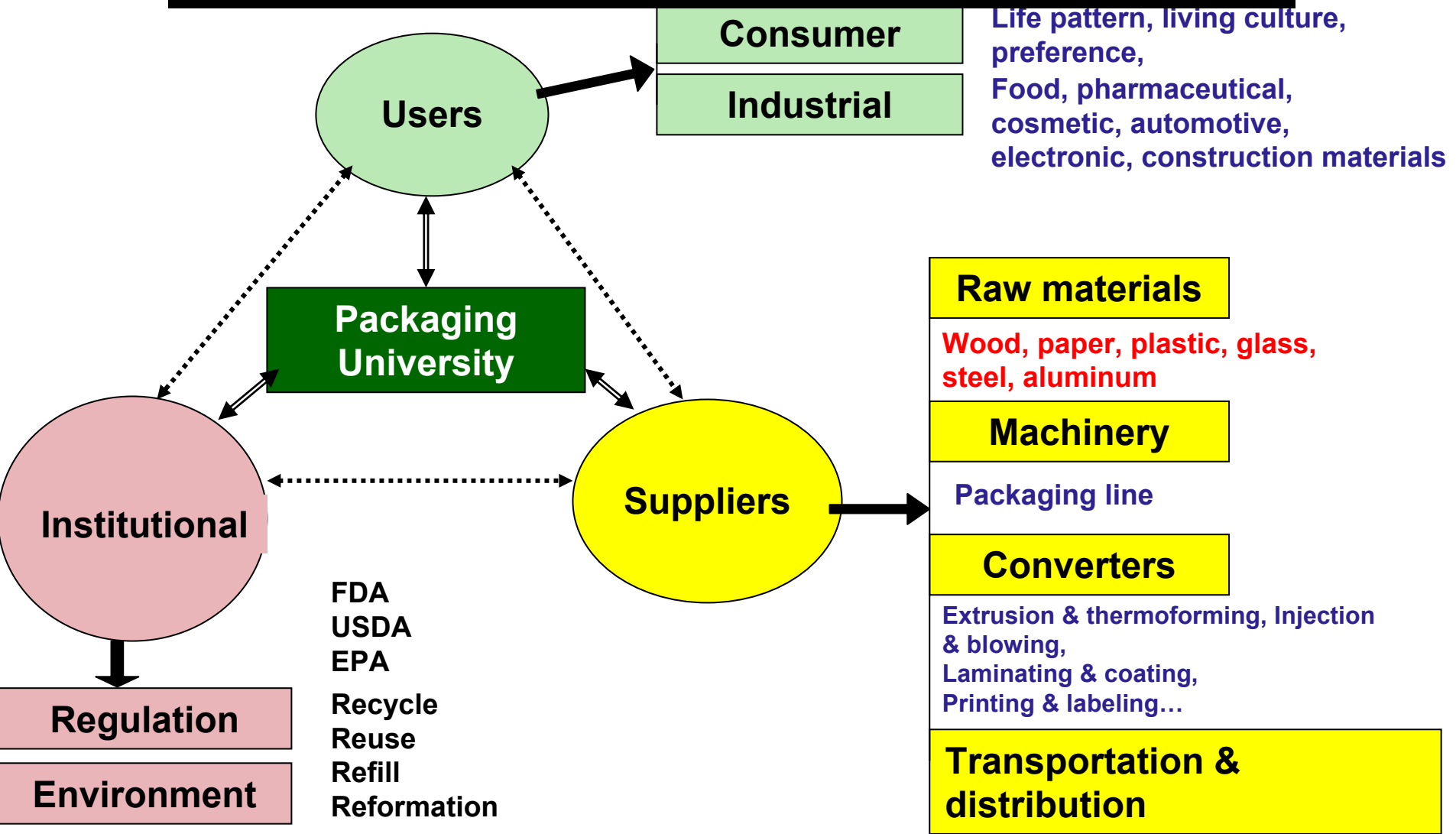


Passive Carton Tag
associated to ...

8 UID Packaging Tags
each with 1 associated
UID item



Why Look to a University?



Packaging Materials

- **Wood**
- **Paper**
- **Plastic**
- **Metal**
- **Glass**

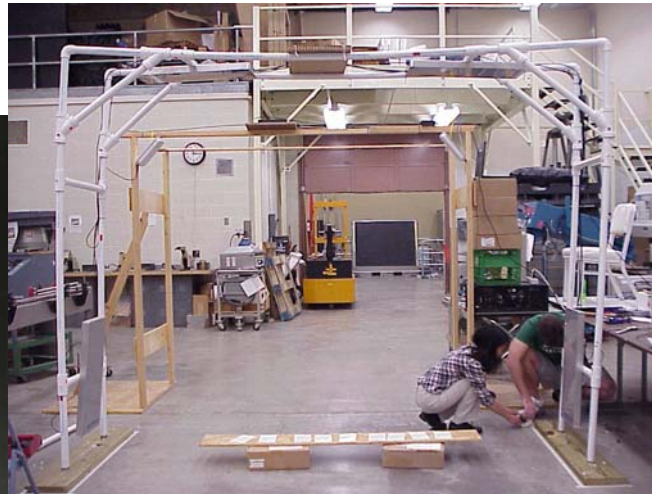
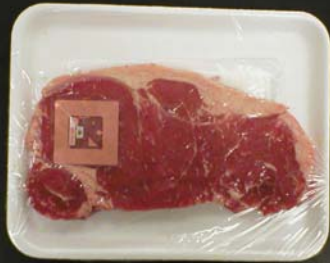
- **P.S., “Cardboard” is NOT a term used within Packaging; it is Solid Fiberboard or Corrugated Board**

Material Impacts on RFID

- ❖ **Different frequencies exhibit different behaviors.**
- ❖ **Metal – large effect.**
- ❖ **Plastic – varies with composition (PP, PET) and thickness.**
- ❖ **Glass – little to no effect (?)**
- ❖ **Paper – little or no effect (?)**
- ❖ **Composites – yet to be evaluated.**

Problematic Matchings

- Packaging and Water-based Products.
- Any Product put in Metal Packaging.



Research to Date

- A Model For The Implementation Of A Radio Frequency Identification System Into A **Warehouse Environment**; Ryan
- Development Of A Material Testing Protocol For Evaluation Of Radio Frequency **Transponder Effects On Bloom Time** Of Beef Loin Muscle; Vorst
- Effects Of **Frozen And Refrigerated Temperature** On Transponder Performance Of Tray-Packed Beef Loin Muscle; Onderko

Research to Date

- The **Effect of Tag Orientation and Package Content on the Readability** of Radio Frequency Identification (RFID) Transponders; Tazelaar
- Determination Of Radio Frequency Identification (Rfid) Tag **Failure Modes** Of Class 0 Read Only Tags; Jonson
- The Effect of **Antenna Configuration, Product and Tag Type** on the Readability of Passive UHF RFID Transponders; Crawford

Research to Date

- **Electromagnetic Property Measurement and **RFID Signal Absorption Evaluation** for Product Simulant; Zhang**
- **Applications And Implementation Of The U.S. Department Of Defense's **RFID Mandate**; Jones**

Results of Total Reads

		<u>TAG ORIENTATION</u>				
Total Tag Read % (Standard Error %)		OUT	IN	FORWARD	UP	DOWN
PRODUCT	EMPTY	100% (0%)	97.1% (0.8%)	100% (0%)	100% (0%)	97.8% (0.4%)
	FOAM	100% (0%)	98.6% (0.4%)	100% (0%)	100% (0%)	98.0% (0.4%)
	EMPTY BOTTLES	100% (0%)	97.0% (0.5%)	100% (0%)	100% (0%)	99.3% (0.2%)
	RICE	99.7% (0.4%)	60.5% (0.9%)	82.6% (0.6%)	82.3% (0.9%)	78.3% (1.3%)
	WATER BOTTLES	67.0% (0.2%)	0.8% (0.3%)	32.3% (0.6%)	25.0% (0%)	0% (0%)

RED = Product Specific **Yellow = Orientation Specific** **Orange = Both**

Material EM Properties Defined by Extracted Parameters

- Complex **Permittivity**(ϵ) , Complex **Permeability**(μ)

- Complex mathematical expression

$$\epsilon = \epsilon' + j \epsilon'', \mu = \mu' + j \mu''$$

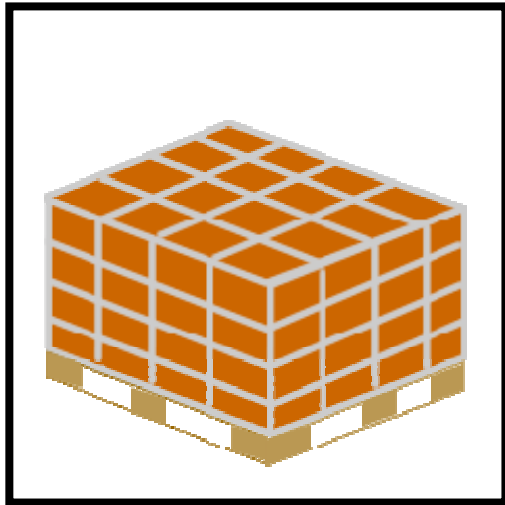
- Where, $j = \sqrt{-1}$, ϵ' =permittivity, ϵ'' =dielectric loss factor, μ' =magnetic permeability, μ'' =magnetic loss factor

- $\text{Re}\{\mu\}, \text{Im}\{\mu\}, \text{Re}\{\epsilon\}, \text{Im}\{\epsilon\}$.

- Real parts are related to the energy storage of the material

- Imaginary parts are related to the loss mechanisms that incident EM radiation into heat.

The Effect of Corrugated Board



Readability evaluation



Determination of
Moisture content

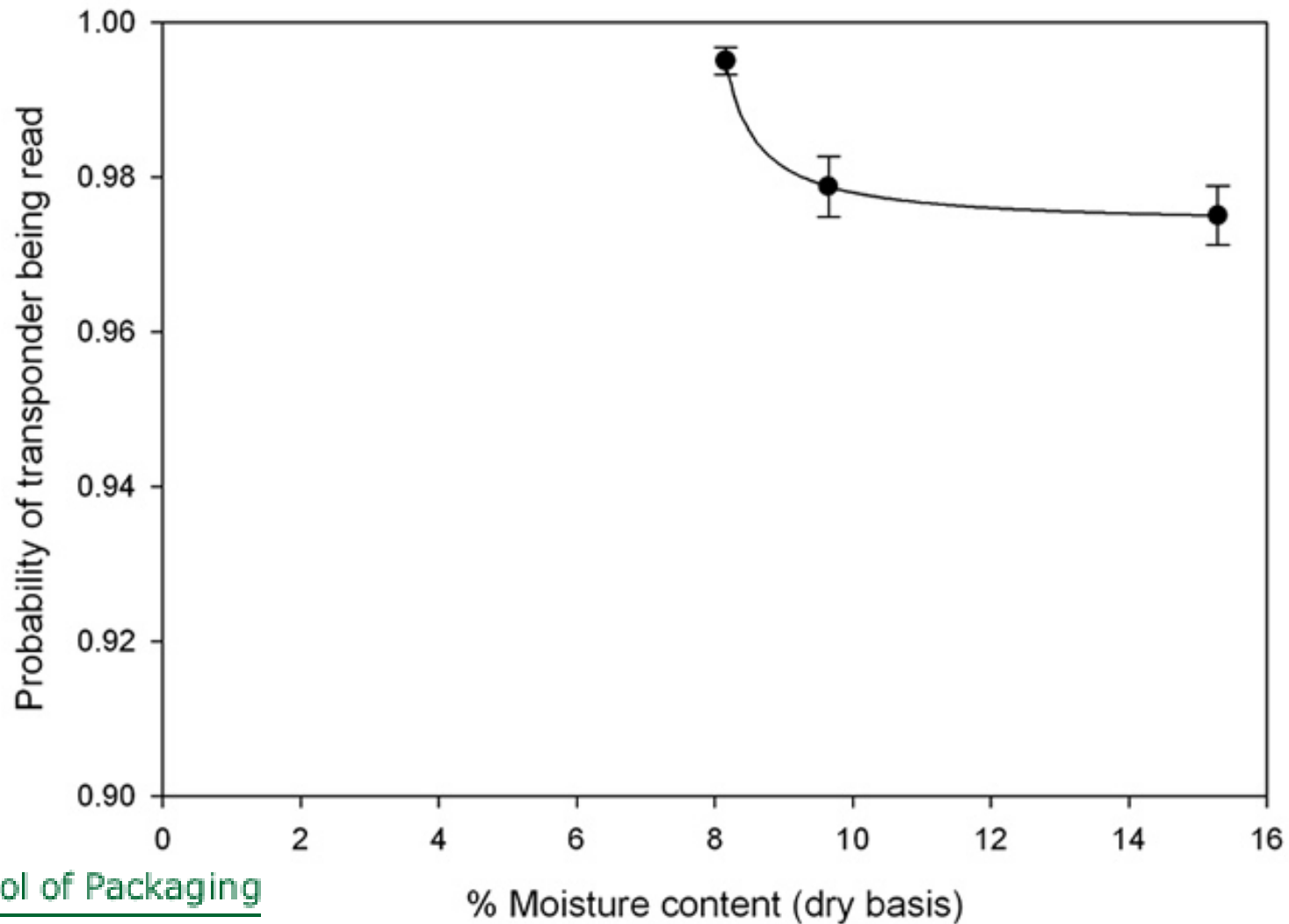
Storage condition

- 22°C, 55% RH
- 29.4°C, 70% RH
- 37.8°C, 85% RH

Moisture content

- 8.2%
- 9.6%
- 15.3%

Readability Affected by Moisture Content



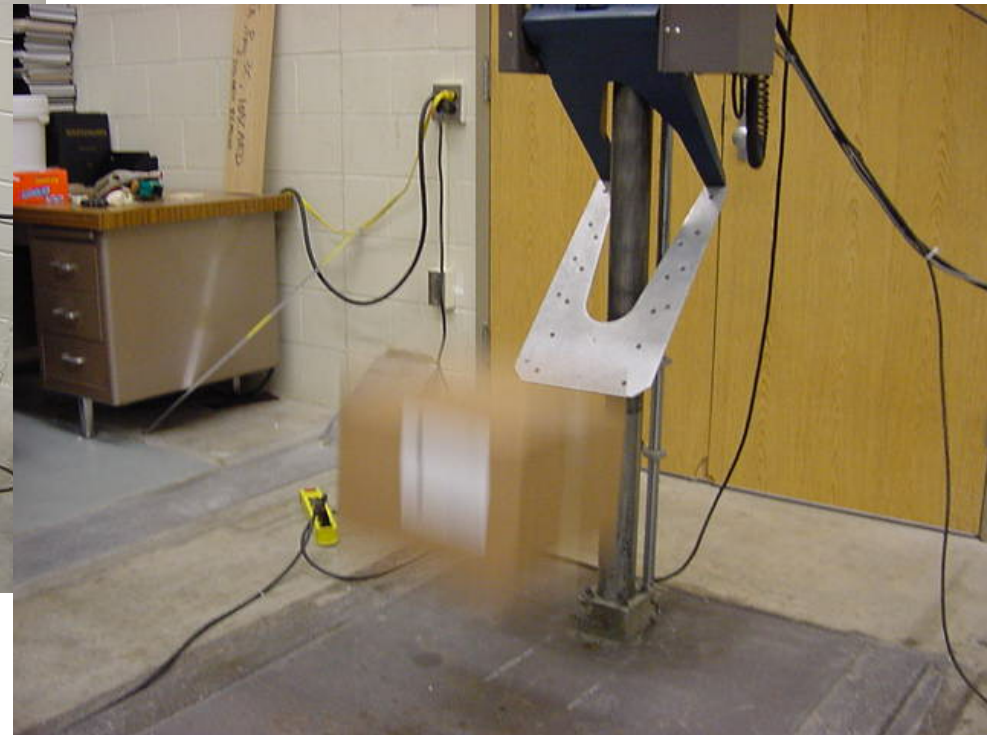
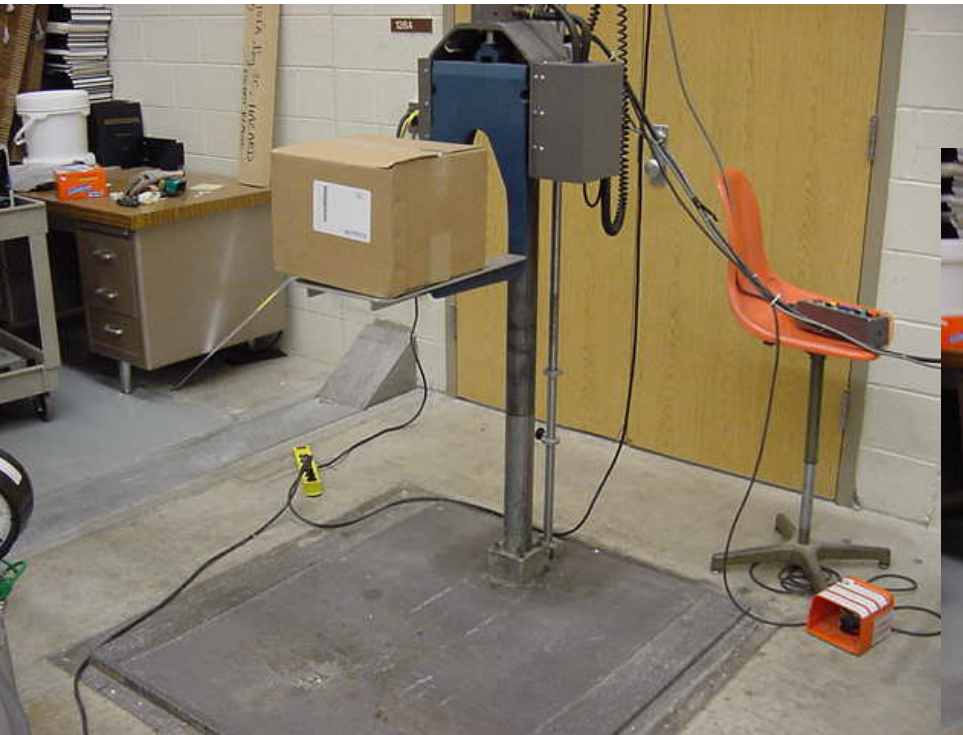
The Effect on Corrugated Board

Corrugated board CAN affect RFID operations:

- High humidity
- Low to medium humidity if:
 - Previously subjected to high humidity
 - Exposed to excessive moisture
 - Leakage of liquid product
 - Condensation
- Relationship to RPC's



Shock Durability Testing on Tagged Cases



Vibration Durability Testing on Tagged Cases



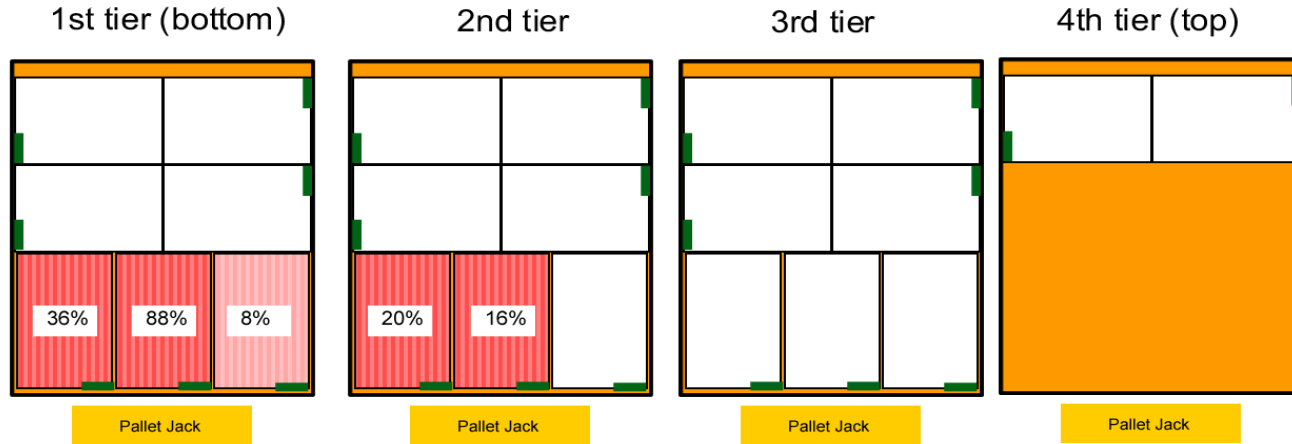
Compression Testing



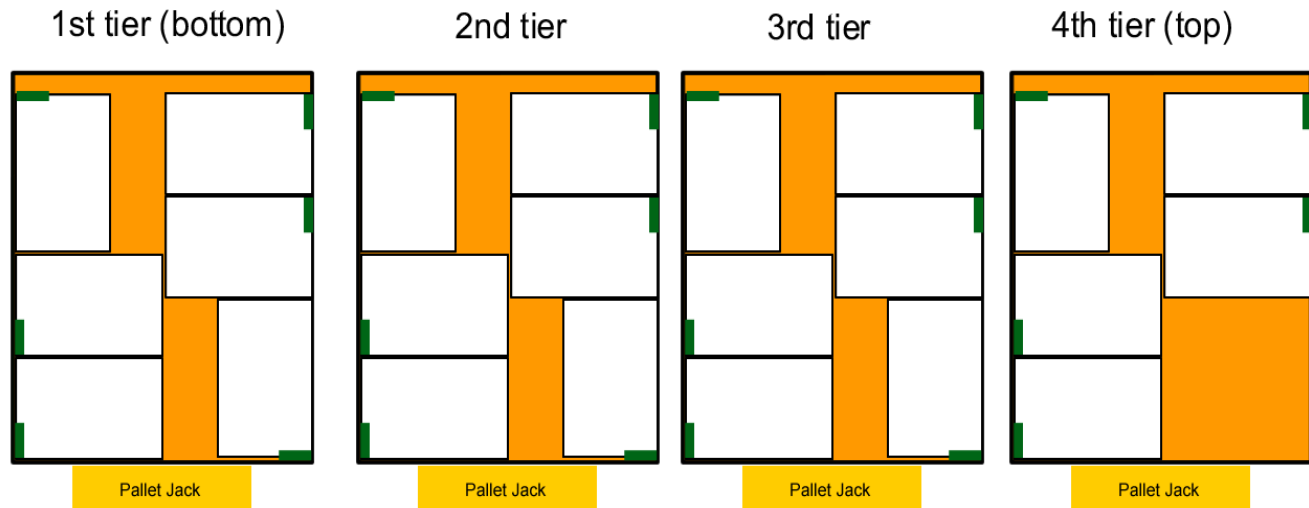
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Optimal Tag Locations

❖ Column stack, tag outward

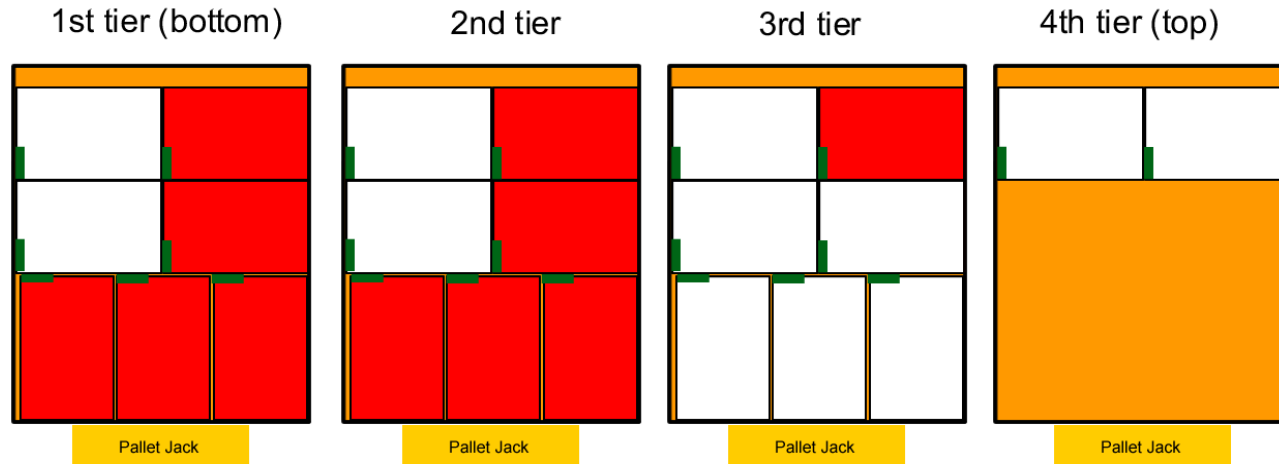


❖ Spiral, tag outward

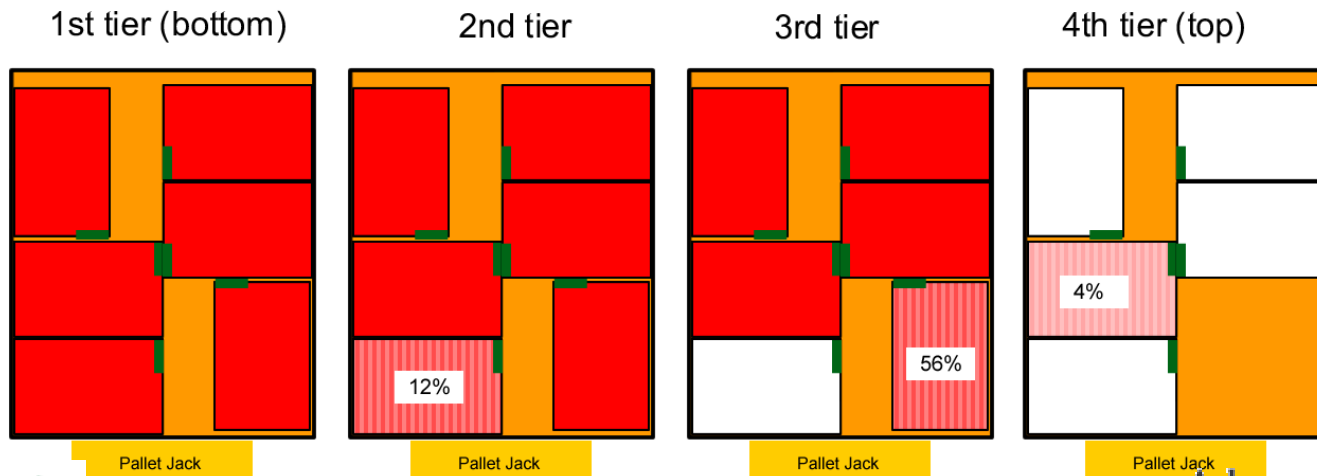


Bad Tag Locations

❖ Column stack, tag inward

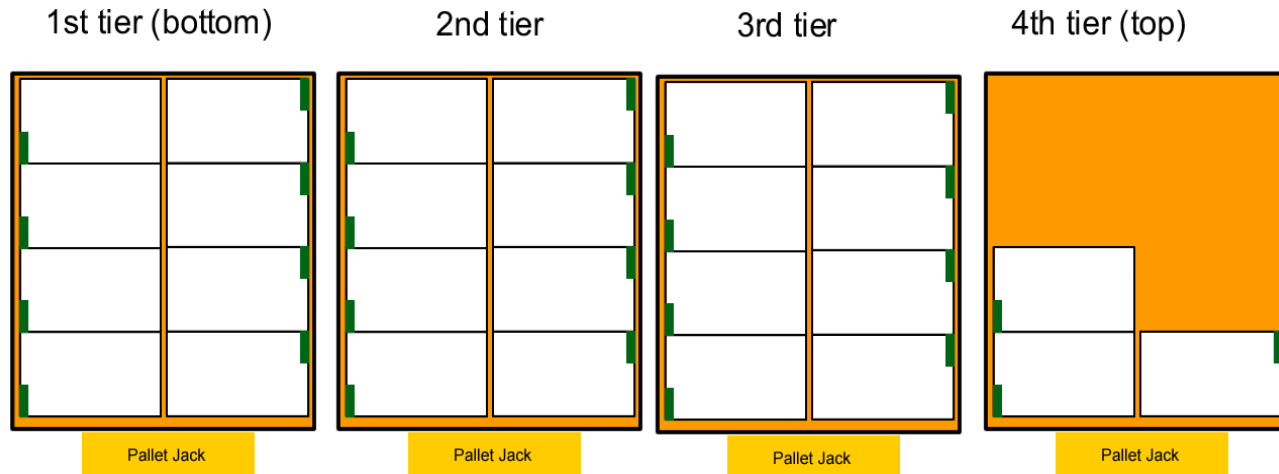


❖ Spiral, tag inward

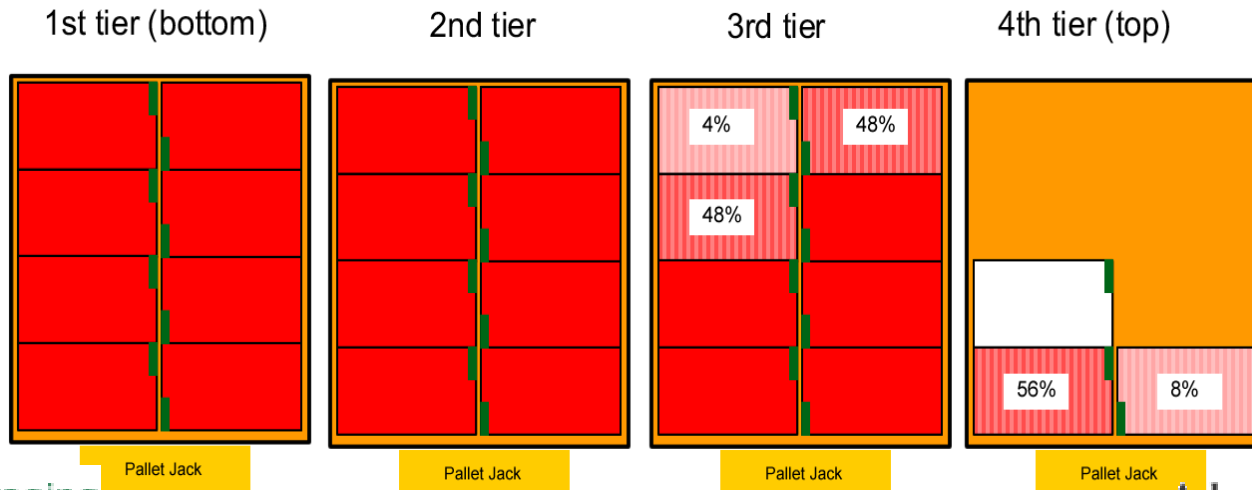


Reversed Tag Locations

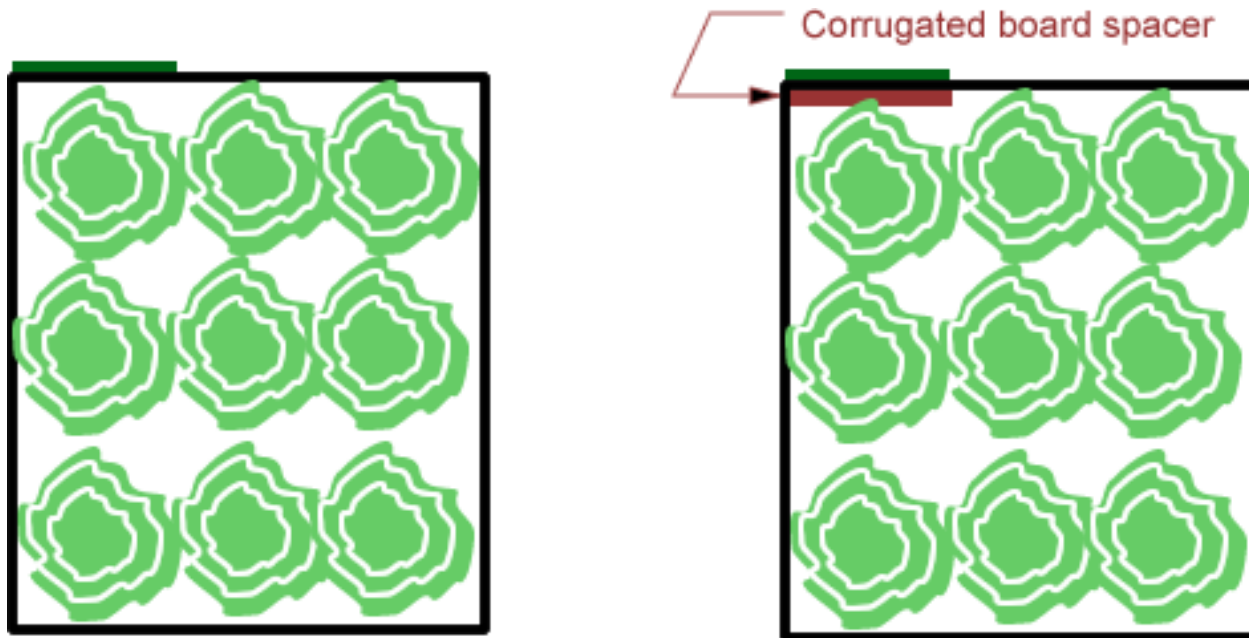
❖ Tag outward



❖ Tag inward



Effect of Corrugated Spacers



Antennae Location and #'s



Water on Corrugated



Water on Corrugated



With UHF Tags:

- Reads stop during water applications
- Reads continue to fail if corrugated is untreated and remains wet
- Reads resume if corrugated is treated and water flow ceases
 - Similar to what happens with an RPC
 - Even if tag is embedded in plastic