Whitepaper

"Tag Feng Shui"

A Practical Guide to Selecting and Applying RFID Tags

Followers of the ancient Chinese practice of Feng Shui attest to its effects on health, wealth and personal relationships. Practitioners of RFID are equally well served by following the guidelines of "Tag Feng Shui" to place and arrange RFID tags to achieve optimal read performance. Understanding the elements of RFID and mastering the techniques will go a long way to achieving a high performance RFID system.

This whitepaper presents practical guidelines for selecting and applying RFID tags, based on Alien Technology®'s deep expertise, developed from numerous production deployments across many industries.

1. Get Your Bearings: Develop the Use Case and Conduct a Site Survey

Start by developing the use case for RFID in your organization, and then conduct a thorough site survey.

Through the use case, you will define the business objectives, the process, and metrics for success for RFID. Do you plan to track assets or locate high-value equipment? Do you want to track work-in-progress or improve warehouse operations? Do you want to improve shipping accuracy? Do you want to reduce out-of-stocks? Is your application targeted at containment, addressing market diversion or alleviating counterfeits? As organizations move beyond customer mandate projects, they are seeing firsthand that RFID can deliver process efficiencies with a clear return on investment.

In developing the use case, you will identify the processes involved and determine which assets should be tagged, such as individual items, cases and/or pallets. Also consider the evolution of the application, so you can design the application to scale to future business

needs. For instance, the use case may call for reading cases on a conveyor, but a longer term goal is to read all cases on a pallet. Building to the minimum requirements now can make it more expensive to scale the application as the requirements increase later.

A site survey is essential to successful RFID system design. Through a site survey, you can identify issues related to RF communications and sources of electromagnetic interference. A site survey is also instrumental in mapping out the antenna RF coverage, power and network architecture. Through the site survey process, you will identify your equipment requirements, such as readers, antennas and applications, and determine ideal placement of these components. The site survey is also a good time to consider the amount and content of data you need in a tag and where and how you will apply the tags.

2. Material Composition of the Tagged Items

Consider the material composition of the items to be tagged. Paper, corrugate, plastics and metal have different requirements. Identify whether the material transmits, reflects or absorbs the RF signal from the reader. Since RF powers the tag, this is critical to performance.

- Paper, cloth and cardboard are transparent to RF, as the RF energy penetrates them relatively easily. Tagging paper and corrugate is straightforward.
- Plastics are reasonably transparent to RF, and are generally easy to tag. But some types of plastics – most notably polycarbonate – can be difficult to tag. Polycarbonate, which is very common, has a high carbon content, which absorbs the RF. Be on the lookout for black plastic, which usually means it contains carbon. In this case, consider a broadband tag like a "World Tag," which has a flatter frequency response and better performance.
- Metal was once considered very difficult to tag. Metal reflects RF, which can be both good and bad. If a standard tag is placed on metal, the conductive surface shunts (shorts) the available energy from the tag. In-phase reflections or re-enforcing waveguides can enhance the signal – or, if out of phase, they can cancel the signal and create a null or dead spot. However, you can successfully tag metal by using an on-metal tag that uses an insulator to space the tag slightly from the metal surface [note: in and out of phase signals depend upon the spacing distance]. In this way, you can reinforce the reflective properties of metal and get better response from the tag.

› Metal or foil packaging also can be RF-difficult, because the metal or foil packaging reflects the RF. Similar to tagging metal, you can use techniques to take advantage of the reflective properties of foil or metal packaging to successfully tag the item. For example, you can design the tag into the foil packaging of a razor or CD such that the metal in the packaging acts as an antenna to focus the RF and get a good response from the tag.

When tagging metal or other RF-difficult items, it's advisable to work with a well-trained solution provider or with the tag manufacturer to design a tag that will work in this application. They will be able to take advantage of unique material properties to optimize the available signal to the tag.

3. Contents of the Tagged Items

The contents of the items to be tagged can also impact read performance.

› Dry materials can be tagged without issue, for the most part.

› Liquid. Water based products are regarded as challenging. Water acts as a large "RF sponge," absorbing most of the available RF energy, leaving little to activate the tag and return data to the reader. But not all liquids react the same: Water absorbs a lot, but contrary to what one may believe (given that it's carbon based), oil doesn't absorb much. In general, oil-based products are RF transparent. Subtle tag antenna designs and tag placement are the keys to performance optimization. Move the tag off the surface, as when tagging metals. For instance, you can tag a wine bottle by placing the tag above the wine or where the glass is thick (alcohol has the same absorptive properties as water).

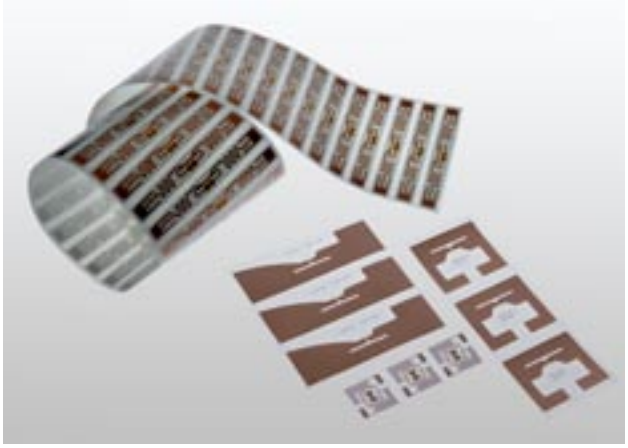
› Semi-liquid. Semi-liquids or pastes can be challenging, depending on the percent of the contents that are water based. For instance, jelly can be difficult to tag, but peanut butter may be found to be easier. Items that contain a lot of sugar can be difficult to tag, because the carbon in sugar absorbs the RF.

› Wood or moist products. Less so today, with more sensitive tags, but some wooden pallets with high moisture content have been know to be challenging as well, because the wood typically used for pallets tends to have a lot of moisture. That's compounded with the reality that pallets are often left out in the rain and the wood absorbs even more moisture.

4. Geography of Operations

Consider geographic compliance. Quite often global tags are needed for items of export so that guaranteed reads can take place at both the country of origin and the point of sale. Global tags typically encompass a very wide frequency band, from 860MHz to 960MHz. A World Tag is variant of a global tag that has a relatively flat frequency response (+/-1.5dB) in addition to a broad bandwidth. This makes them ideal for difficult read environments or challenging applications.

5. Size of Tagged Items



How large are the items to be tagged? Keep in mind that smaller isn't necessarily better when it comes to tags. Tag performance generally decreases with size, so it's advisable to use the largest size possible that fits the object. Consider high volume, general purpose mainstream tags, and then migrate to high-end or custom options if necessary. If the item is difficult to tag, you may want to select a tag designed for high performance. If dimensionally restricted, and a vertical orientation is desired, then consider use of a 2x2-inch square tag.

6. Tag Placement and Application

First, discard the bar code mentality: Ideal RFID tag placement is not the same as for bar code labels, which are traditionally placed in the lower section of a case. Think about where to place the tag, balancing performance and aesthetics. Investing the time upfront to determine the optimal location for the tag will save money in the long run. For example – if the case contains aqueous material in bottles for example, aligning the tag with the air spaces between bottles will improve read performance.

Second, consider new labeling options when tagging cases. Placing the tags on the inside of a box (instead of the outside) can deliver the performance you need and keep marketing content.

Avoid placing tags symmetrically on cases, which will help alleviate "shadowing" at the pallet level. Shadowing occurs when multiple tags are placed very close to one another, and the tag antennas "hide" or detune each other, which reduces the chance of reading the "buried" tags by minimizing their chance to be activated. Keep in mind that technological advancements in certain RFID tag silicon and tag antenna designs have greatly alleviated this problem.

Consider how the tags will be applied. Studies indicate that manual application costs can approach $5 per case. For high volume applications, it's far more cost effective to invest in an automated applicator than to do slap-'n-ship. Using an automated applicator to program and apply the tags will improve the reliability of the reads and ultimately be less expensive to operate. Consider the optimal location for the applicator – be it a hand applicator or a printer applicator on a conveyor – or at the corrugators. Automated processes are essential to minimizing the cost of the case tagging process.

Wet-inlay applications are becoming more cost competitive with traditional dry-inlay techniques used in the past. (A wet inlay is essentially a label without the printing.) Innovative converters have new capabilities that can merge the wet inlay to the label stock at high rates of speed.

7. Required Read Range

Is the required read range in feet or in inches? How densely packed are the tags? How fast are they moving? Longer ranges require larger tags, and it's a reality of physics that with longer ranges, the read rates are slower, and more reader power or more sensitive tags are needed. Extra range may be required if the application calls for reading a large number of tags moving very quickly past the antenna. The more challenging the application or environment is, the more read range you should have to ensure success.

Conversely, read ranges of a few inches can be achieved with a very small tag and lower reader power levels. Far fields are typically used for longer range applications, such as reading cases or pallets through a conveyor or dock portal, but they can also be useful in reading tags in very close proximity.

8. Read Success

Success isn't about benchmarking read rates in a lab. Success is about performance in the real world. Read success is impacted by many factors, but you can improve read success by smartly taking advantage of the environment, including motion, using multiple antennas and tag orientation.

Whether an item is stationary or moving also impacts read success. Motion generally helps with difficult products, such as when reading cases on a pallet on a turntable. But some motion is too much. A pallet of tagged cases is easier to read when sitting on the dock than going through a dock door on the forks of a forklift at 10 MPH. And the metal of the forklift doesn't help. As part of the site survey, look for how the tagged items will move through the facility and this will guide your optimal placement for readers.

Examine the material flow to determine reader location. Look for choke points, through which all products must flow, and then use that information to determine the antenna location. Using multiple antennas in a reader can also help. Reading items one at a time as they go down the conveyor is easy and highly accurate, because readers can be placed on either side of the target or even overhead. A pallet can be read while it's stationary on the forks of a forklift, but if that forklift has an integrated reader, the reads will, in general, be more accurate. Forklift readers are usually very limited in RF "scope" – generally focusing on reading the pallet tag rather than the case tags. A pallet of tagged cases can be easily read with a reader mounted on the arm of a stretch wrap machines. Kanban carts containing work-in-progress inventory can be read as they move through manufacturing, as they are typically low speed and not densely packed. Also consider the composition of the carrier that's used to hold the item. Whether the pallet is wood or plastic impacts performance or whether the bin is plastic (or made of polycarbonate).

Tag orientation also impacts read success. Whenever possible, try to vertically orient dipole tag antennas. Horizontal orientations are prone to miss-reads due to "perpendicular" or "cross"-presentation. If you cannot control the tag orientation, use circularly polarized antennas because they are most accommodating for various tag orientations. Linearly polarized antennas are an excellent choice for challenging applications where tag orientation is controlled. For instance, linearly polarized antennas are typically used for tollway applications and reading tough cases within a pallet in a manufacturing site.

9. Aggregation

For certain items, reading a full pallet at 100% accuracy is difficult, and the difficulty level increases when the pallets contain mixed cases. The best approach to this knotty problem is aggregation, which will ensure that all tagged items are accounted for. In aggregation, items are rolled up to the case level, and then the cases are rolled up to the pallet level. As part of this process, each tag is associated with the next higher level tag. The tags are commissioned during each phase of the aggregation, for instance, from item to case and from case to pallet. Aggregation is highly effective whether all the items are the same or are mixed.

10. Environmental Interference

A proper site survey will identify existing in-band RF sources that may present co-existence challenges. The presence of multiple RFID readers, industrial machinery and vintage 915MHz wireless access points and wireless alarms or monitoring systems may be sources of interference. Solutions include shielding the interference, increasing the power on the readers, and using higher performance tags.

The construction of the building itself—whether it's a glass-and-steel office building or a brick warehouse—also matters. For instance, a concrete building has a lot of steel rebar, which may reflect RF – to both good and bad effect.

Achieving Tagging Success

By taking into consideration these ten elements that impact RFID tagging success, you can improve the performance of your RFID application and achieve the sought-after efficiencies promised by the technology more quickly and easily.

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