WHITE PAPER

RFID Tag Selection

5 Considerations for a Successful System Implementation

LOWRY SOLUTIONS

Executive Overview

The continued growth in RFID adoption for asset management, inventory control, work-in-process tracking, manufacturing process control and supply chain operations has led to a seemingly unlimited number of RFID label and tag options.

In spite of numerous options, there are still items and environments that present significant challenges when it comes to RFID tagging. Additionally, business operations, information needs, and user requirements vary greatly.

With a focus on UHF passive RFID, this paper will address the benefits of RFID and the considerations necessary for selecting the proper RFID label or tag for the application. By taking the appropriate factors into consideration, users can achieve business process improvements utilizing RFID.

RFID Benefits

Radio frequency identification (RFID) is an automatic identification and data collection (AIDC) technology that uses radio frequency for communicating data between an RFID tag and an RFID Interrogator (reader). More than that, RFID is a business process improvement tool that increases efficiency, accuracy and business intelligence.

Users of a well-deployed RFID system benefit from:

- Increased productivity
- Increased order & shipment accuracy
- Reduction in human errors
- Reduced cost of inventory management
- Enhanced compliance
- Higher levels of customer satisfaction
- Reduced costs
- Increased profits

Tag Selection

In spite of the numerous RFID tag and inlay options available today, tagging items remains as one of the most significant challenges to implementing a successful RFID system. Before engaging in the effort to tag your items, you should take some time to consider the workflow and business processes associated with the items you wish to tag.

For example, if you are tagging a medical instrument, at some point in the workflow it may go into an autoclave. It is important that the tag can survive the autoclave process. Another example is a tool on a bench that may have many areas that a tag can be attached and will read, but when the tool is used to maintain a piece of equipment, there may be a clearance that is no longer achieved because of the addition of the tag.

Understanding the lifecycle of the item(s) will ensure that the selected tag will enhance, rather than interfere with those processes. Additionally, taking into consideration the five factors of tag selection will further ensure a successful system deployment: Read Range, Environment, Application, Data Requirements, and Size.

Frequency

The frequency is the radio channel that the RFID system communicates on, like your car radio. The radio station is transmitting at a specific frequency. In order to hear that radio station, you need to set your car radio dial to the same frequency. This is the same for RFID systems. Your tags must be the same frequency as the reader. Sometimes you will hear frequencies referred to by the frequency band that they fall into. For example:

Low Frequency (LF): 30 – 300 kHz
High Frequency (HF): 3 – 30 MHz
Ultra High Frequency (UHF): 300-3000 MHz

Depending on the country that you are in, you may be limited to which portion of the frequency band that you can use or the transmit power permitted. For example, in the United States this is enforced by the Federal Communication Commission (FCC).

Different frequencies have different advantages in specific applications. Specific frequencies may have a higher data rate, longer read range or may perform better in the presence of water, metal or other material.

The frequency band that you are using is often selected for you. The industry that you are in may already have standards in place for interoperability of systems. For example, if you are shipping product to the Department of Defense or to a major retail store, the frequency that you will be using is UHF. They have all agreed to enable the global supply chain to be interoperable by using EPCglobal® Standards. The EPCglobal® standards for supply chain applications use the UHF band and in the United States they only use the 902 – 928 MHz portion of this band.

The EPCglobal® standards specify the frequency of the RFID tags, the communication protocol and the data structure so that the RFID tag can be used through the entire supply chain. More information can be found at: http://www.gs1.org/epcglobal/.[1]

There are two types of Radio Frequency tags, active and passive.

The general rules are as follows:

Active	Passive
• The tag talks first.	• The interrogator (reader) talks first.
• The active tag has its own power source (a battery).	• The passive tag has no power of its own; it is powered by the radio signal from the reader.
• The active tag generally has a longer read range than a passive tag.	• Passive tags generally have a shorter read range than active tags.
• Active tags can support sensors for temperature, humidity, etc…	

The above are general rules and there are exceptions. For example, there is also a tag known as a battery assisted passive tag or BAP. BAP tags follow the general rules of a passive tag, but contain a battery that is used to extend the read range or the functionality of the tag.

Once the frequency of the RFID system has been determined, the following five factors must be considered before an RFID tag or label can be chosen.

Read Range

Read range is simply the physical distance between the tagged assets and an RFID reader. Each RFID tag or inlay has a specified read distance when used in its optimized environment. Today, UHF Passive RFID tags vary in read range from just a few inches up to a hundred feet.

Tags can be read using fixed (stationary) readers or handheld readers. Fixed readers are permanently installed in a defined area and are always ready to detect any tag

that moves into its read zone. They may be installed at dock doors to capture the shipment or receipt of palletized goods, or installed on high-speed conveyor belts to read products as they move down an assembly line.

Handheld readers are chosen to allow a user to bring the device to the point of work or the tagged items, rather than moving tagged items past a fixed reader.[2] As a rule of thumb, fixed readers will have a 25% greater read distance than handheld devices.

Environment

The environment in which your tagged asset will live is very important. If it will primarily be housed outdoors or exposed to moisture, chemicals, low or high temperatures, then the encasement of a tag or the label material and adhesive will play a big factor in selection.

A passive UHF RFID tag's performance can be significantly decreased if there is metal or liquid in the surrounding environment, as both substances interfere with RF signals operating in the 860-960 MHz band—water absorbs the radio waves while metal reflects them.

There are many specialty tags on the market today built to perform in these RF-unfriendly environments. Likewise, label materials and adhesives can be customized to survive in these harsher environments.

High temperature applications remain as one of the most challenging environments for RFID tags today. While there are tags advertised to withstand temperatures as high as 600° F, the exposure time and the number of cycles that an item will be exposed to specific temperatures must also be considered. Extreme temperatures can damage the chip IC, resulting in inconsistent read performance.

Application

Application refers to the actual material makeup of the item to be tagged or the surface to which the tag will be attached, the method of attachment, and where the tag will be attached.

Surfaces such as corrugate and plastic are considered to be RF-friendly, so a standard pressure-sensitive RFID label should work well when tagging these types of products. One exception is when the item being tagged contains liquids. There are some inlays that perform better than others in the presence of liquids, but additional testing is always required in these situations.

Just as the presence of metal and water in the RFID system's surrounding environment may pose challenges, so will the actual tagging of those types of items. In these instances, tags that have been specially constructed to minimize the RF interference of these substances must be chosen.

The differences between RFID labels and hard tags are described below. Understanding these differences brings you a step closer to selecting the type that is best suited for your specific system.

Labels/Inlays vs. Hard Tags

An RFID tag is made up of a chip and an antenna. The chip may be as small as a grain of sand (about .3mm2), but the antennas are much larger. This assembly is known as an RFID inlay and can be converted into a pressure-sensitive adhesive-backed label, a hang tag with no adhesive, or embedded into a variety of more durable materials such as ABS plastic or silicone.

Finished RFID labels and hang tags are manufactured by label converters that have invested in specialty RFID presses and other types of RFID insertion equipment. A label converter that has made these investments and that has RFID experts on staff who understand the complexities of the technology can help design a product that will meet the printer/encoder manufacturer's specifications for proper inlay placement in the label or tag.

When not properly placed within the label, the chip cannot be encoded and therefore will not perform. Additionally, converted labels/tags can be made into numerous customized shapes and sizes in a wide variety of material and adhesive combinations, limited only by the size and form factor of the inlay.

Inlays that are embedded into other materials or encased for environmental protection and additional durability are often referred to as hard tags, ruggedized tags or on-metal tags. On-metal tags are constructed in such a way that they can be affixed directly to metal surfaces or surfaces containing liquids without compromising read performance.

Options for affixing an RFID label or tag include pressure-sensitive adhesive, foam adhesive, Epoxy glues, rivets and zip ties. The method of attachment you choose may depend on where the tag needs to be placed.

Tag placement needs to be carefully considered and varies greatly between asset types. Always place the tag where it will easily present itself to the reader and where it will not interfere with the day-to-day operation or functionality of the item.

Data Requirements

When selecting an RFID tag, data requirements are another important consideration. You will need to consider the amount of data that needs to be encoded in the chip as well as any other requirements, such as having the data human readable or including a barcode. This may dictate the type of tag and the encoding/imprinting method.

In some cases, the data requirements are defined by your customer. For example, when providing products to the retail industry or to the Department of Defense, you may be instructed to encode to a specific EPCglobal® standard. The GS1 EPC Tag Data Standard2 has defined data structures for:

- Serialized Global Trade Item Number (SGTIN)
- Global Location Number With or Without Extension (SGLN)
- Global Individual Asset Identifier (GIAI)
- Global Document Type Identifier (GDTI)
- US Department of Defense Identifier (DOD)
- Serial Shipping Container Code (SSCC)
- Global Returnable Asset Identifier (GRAI)
- Global Service Relation Number (GSRN)
- General Identifier (GID)
- Aerospace and Defense Identifier (ADI)

Some of these tag data formats may require as little as 96 bits of data to encode the required data. Refer to http://www.gs1.org/epcglobal for more information on tag data formats.

There are other industries such as the Aerospace industry that have requirements for high memory RFID tags. High memory tags are used for applications such as Aircraft Maintenance, and configuration management. High memory tags come in different memory sizes, but will generally be rated in kilobytes and not bits.

With the variety of chip memory configurations available today, it is possible to encode a tag to meet a customer compliance requirement, and still use the RFID tag for an internal business process. The required customer data format can be encoded in the “EPC” portion of the tag memory and the remainder of the tag can be encoded for your own internal business intelligence.

Most converted RFID labels can be printed and encoded in an RFID printer in high volumes at a reasonable rate of speed. Additionally, this gives the user the ability to print and encode “on-demand” which is often a requirement when variable data or date/lot/batch information needs to be captured at the point of tag commissioning.

With hardened, or encased, RFID tags which cannot be run through a printer, encoding can be done at the tag manufacturer, by a systems integrator, or even by the user. However, if deploying a large number of tags at one time, encoding the tags individually with a handheld or fixed reader can be a labor-intensive and time-consuming process.

New, print-on-demand, RFID labels that can be attached directly to metal surfaces or items containing liquids have been developed by a few RFID tag manufacturers. These tags are compatible with industry-leading thermal transfer RFID printers and provide the user an increased amount of flexibility and control over tag commissioning that until very recently, was not available.

Size

The size of the tag you select is dictated by the size of the asset being tagged and is dependent on the space available to place the RFID tag. On many assets such as shipping containers and vehicles, there is plenty of available space to successfully affix a tag, but available real estate on smaller assets can be very limited. A tag must not be placed in an area that could potentially compromise a product's functional purpose.

Over the last several years, RFID tag and inlay manufacturers have responded to the need to tag very small, high-value assets such as prescription drug bottles, tools, and electronic equipment where available space to place the tag is limited. As a result, there are many tag options now available on the market, but it is important to remember: the smaller the tag, the shorter the read distance.

Testing

Laboratory testing and manufacturer's published specifications are a good start to help narrow down tag options and get a baseline on a tag's read performance on specific items. However, there is no substitute for field testing in the actual environment(s) that a tag will live and travel. Additionally, there is no guarantee that a tag that performs perfectly in our lab will behave the same way in your facility.

Additional Considerations

When tagging multiple types of items with differences in material makeup and size, it is tempting to choose a different tag that has been optimized for each specific situation. However, whenever possible, try to select one tag that will perform equally on all of your items. Standardizing on one tag allows users to take advantage of cost savings achieved by higher volume purchases.

Summary

Narrowing down the options to the best performing tag can be a time-consuming and tedious process, but still one of the most crucial steps in deploying an RFID system.

Partnering with a knowledgeable systems integrator that has access to all of the latest RFID tags, and/or an RFID label converter can cut down the amount of time and testing required by an organization and in turn, provide a faster ROI.

> *"If you issue a general request for information, a vendor might return a thousand RFID tags—even if they have never even heard of your scenario. We don't have the time or the knowledge to whittle that down to a handful of tags that would be right for us. Lowry gets us to that level by recommending RFID products that fit our applications and our budgets."*
>
> Dave Zuwala, RFID Consultant
> Dow Corning Corporation[3]

Works Cited

1. GS1 AISBL. 2013. *GS1 EPC Tag Data Standard 1.7.* GS1.
2. Intermec Technologies Corporation. 2007. *Practical Uses for RFID Technology in Manufacturing and Distribution Applications. Everett: Intermec Technologies.*
3. Avery Dennison RFID. 2008. *Dow Corning, Lowry Computer and Avery Dennison Builds RFID Solution for Challenging WIP Application. Miamisburg: Avery Dennison RFID.*

About Lowry

Since 1974, Lowry Solutions, Inc. (formerly Lowry Computer Products) has helped its customers make informed business decisions and become more competitive in the marketplace. The company provides the most innovative barcode, RFID, biometrics, enterprise mobility, asset management and inventory control solutions that reduce operational costs, heighten productivity, and improve process efficiency in an array of vertical markets. Its enterprise mobility solutions empower the mobile worker through real-time communication and data access solutions. See more at *www.lowrysolutions.com.*

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