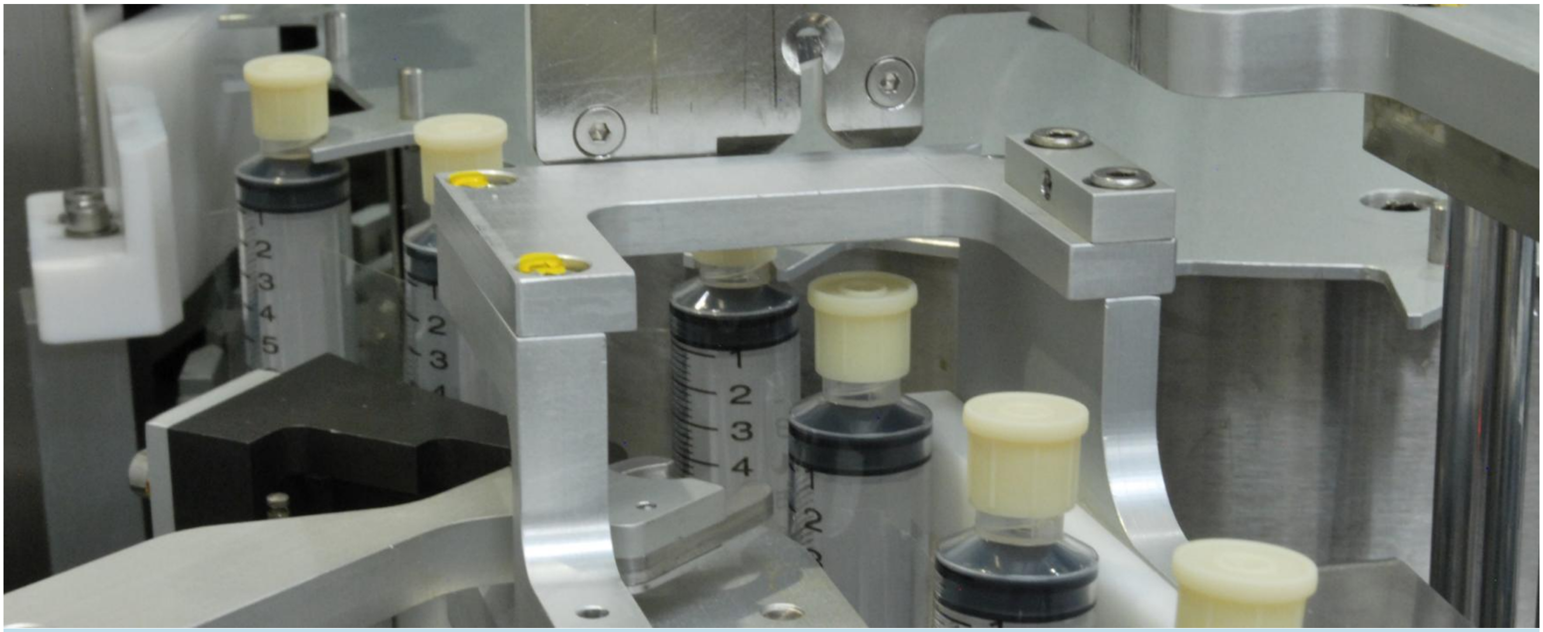

IntelliFill® i.v.
Radio Frequency Identification (RFID)

INTRODUCTION

Radio Frequency Identification (RFID) is rapidly emerging as an alternative to bar coding for automatic identification of items and people in the healthcare environment. Its primary advantages involve proximity reading, not requiring a line of sight and the ability to read multiple identifiers and potentially large data content in rapid succession.

The key elements of an RFID system are the tags, which contain radio-addressable data, and the readers, which energize the tags and then read the responding information.

Tags consist of a microprocessor that contains data, hooked to an antenna that can receive radio activation and transmit the tag's data back to the energizing reader. Most tags are passive in that they have no internal power, but can generate enough power when energized by a reader to transmit the information they contain back to that reader. Active tags, by contrast, contain their own internal power supplies and continuously broadcast their information.

Some tags are read-only and contain a globally unique identifier that becomes linked to a larger database record when the tag becomes associated with a specific item.

Others are Write Once – Read Many times (WORM) tags that feature contents written when the tag is first defined, and then read as often as necessary. The writing may be done by the tag manufacturer or the user of the tag the first time it is used.

Some applications (such as automotive manufacture) use read/write tags with large data spaces on which they store manufacturing instructions, as well as manufacturing history information, as an item moves through the assembly process.

Tags themselves must be placed in some kind of application substrate (e.g., a printed label, embedded within an object, etc.) along with their antenna in order to be useful.

RFID FREQUENCY, RANGE AND SPEED

RFID systems operate within one of the following frequency ranges:

- **Low Frequency (less than 135 KHz)** – provides limited read distance (0.33 m), requires very little power and allows for good penetration of metal and water-containing objects
- **High Frequency (13.65 MHz)** – read range up to 1 m, provides better data throughput and is good around metals
- **Ultra-High Frequency (860 - 960 MHz)** – read range is in 10s of feet, provides faster data transfer, but requires more power
- **Microwave (2.45 GHz)** – expensive

Signal strength varies inversely with distance. At best, signal strength varies inversely with the square of the distance ($1/d^2$) but can vary as much as a distance to the fourth power ($1/d^4$), depending on environmental interference. Interference is most significant with metals, water and organic materials.

Similarly, data throughput varies with distance and power. For example, high-frequency data transfer can approach 2 Mbps in close proximity but can get as low as 75 Kbps at the limits of its range.

RFID COST

The cost of the individual RFID tags varies with the frequency and range desired, as well as the amount of data to be stored. A typical tag may store as much as 2 Kbits of data and costs $0.60 each.

Walmart Corporation and the US Department of Defense (DoD) have established an electronic data standard called the Electronic Product Code (EPC) that they now require to be encoded on items delivered to, and provided within, their systems. This standard identifies a 64- or 96-bit data standard within an RFID tag at the high-frequency range, intended to provide the same level of functionality as the UPC bar code on most retail items. This mandate has driven the cost of these tags down to the range of $0.20 each.

EPC is a standard promulgated by EPC.org, which intends that widespread adoption of this tag style will result in tags eventually reaching the range of $0.05 each.

A 96-bit data tag provides 79,228,162,514,264,337,593,543,950,336 unique combinations, enough to provide unique syringe identifiers for 10,000 IntelliFill i.v. devices producing 6,000 syringes daily for 3,617,724,315,719,832,767 years. The actual size of the unique identifier varies with the encoding scheme, of which there are already several. Even within these limits, the serial number can vary between 25 and 36 bits, representing 33,554,432 to 68,719,476,736 unique serial numbers. Since each of these also permits a unique identifier of up to 28 bits to encode the provider (in this case, the hospital), this number of possible combinations would be available to each institution, permitting 15 to 31,378 years of activity per device before the serial numbers would repeat themselves.

Typical substrate costs add between $0.01 and $0.10 to the cost of the applied RFID tag.

RFID CONTENT

The topic of information content mirrors that of bar codes and follows one of two branches:

- **Pointer** – The bar code or tag contains a number, or other unique identifier, that permits the application receiving the scan results to look up item information in a database. Current bar codes on retail items perform this function. The EPC standard effectively follows the same paradigm. For implementation of RFID, tags are relatively inexpensive, the content is fairly small and the burden for resolving the pointer on the tag to an item identification is placed on a computer system with databases that already exist for this purpose.

- **Data** – The bar code or tag has large capacity and actually contains a data structure that holds significant information about the item. This is the paradigm used in automobile manufacturing, printed postage bar codes and the 2-D bar codes that are finding use in a variety of applications. Where the amount of necessary data is constrained, this technology permits the scanning system to display and/or react to the information without having to perform additional lookups.

Healthcare applications appear to be moving toward the latter course, because having all the information contained in the scannable marker reduces the need to maintain lookup databases and/or connectivity to external systems for such lookups. Especially where such marking is used for Bar Code Medication Adminstration (BCMA) systems, this permits the bedside system to display and process the dose information without having to first look it up in an external database.

TECHNOLOGY CONFLICTS/LIMITATIONS

While this technology shows a lot of promise, there are outstanding issues:

ITEM ISOLATION/SPECIFICITY

RFID establishes a read range and reads all tags at the scanner frequency within that range. This is a benefit to applications that want to itemize all readable tags within an area, but creates problems in the case where the scanner must distinguish a particular tag among other tags in close proximity.

Specifically for IntelliFill i.v., this means that embedding tags in syringes banded together, and then attempting to read a particular syringe in order to assign its RFID serial number to a syringe order, may be technically challenging.

INTERFERENCE AND ABSORPTION

The automation deck of IntelliFill i.v. contains a number of metallic parts and the syringes contain fluids, both of which are known to compromise RFID scanning.

Interference is likely to be most pronounced in mass scanning applications where a scanner might, for example, need to report all the syringes in a refrigerator, highlighting those that were about to expire. Interference would accrue from the metal components of the refrigerator, the water in the doses themselves and the obscuring of one tag by another.

Literature hints that there is a failure rate that is inherent in mass scanning activities like this because of interference, but the rate of such failure is not documented.

LACK OF STANDARDS

Currently the only standards in this field relate to commerce with Walmart and/or the DoD (EPC). Experience with bar coding suggests that healthcare likely will not follow commercial standards. This makes early adoption of RFID risky at best, since it cannot be known at this point which frequency range will be selected for healthcare use, nor can it be readily known at this point what data format and content standards will be selected.

COST

At best, this technology will add approximately $0.15 to each item tagged. For use with each dose on an IntelliFill i.v. device, other economies would have to be located that would create the economic space to fund this technology.

The lowest-cost items are the EPC tags that are designed to carry only numeric serial numbers, which severely limits their usefulness in applications where data transfer would be valuable.

APPLICATIONS TO INTELLIFILL i.v.

Presuming the cost of applying an RFID tag to a syringe produced by IntelliFill i.v. is within an acceptable range, one can envision a variety of potential applications that variously use the “pointer” or “data” approach to the use of an RFID tag.

SYRINGE MARKING

One can envision a scenario in which each syringe contains an embedded RFID tag marked with a unique number that points back to a record of its manufacture. IntelliFill i.v. could use this number, rather than an internally generated syringe identification number to track this syringe throughout its production cycle. IntelliFill i.v. would then have to report the association of the unique tag ID to other systems so they could use it as well, or the use of the tag would be limited to IntelliFill i.v.

Such a tag would have to be uniquely scannable to permit IntelliFill i.v. to isolate and record the electronic signature of that individual syringe.

Ideally, such a tag would have a low cost, would require a close proximity read and its number would be used as a pointer into the IntelliFill i.v. logs that would identify that unique syringe with its entire production history.

The benefit from such a tag would accrue in places where BCMA system requirements prevented unique marking of the syringe with a bar code. The bar code on the label could support dose identification within the BCMA system, while the syringe tag would support unique syringe identification within IntelliFill i.v. during dose verification.

Indeed, one could envision a scenario in which labeling of a syringe occurred outside the automation deck. The syringe, once released from IntelliFill i.v., could be manually verified and an external printer could print the label for application to the syringe after a pharmacist had determined it had been properly made.

COMBINATION LABEL AND TAG

Another application might be to replace the current label with a combination printed label and RFID tag, on which the current standard bedside-oriented information would continue to be printed, while the production information (i.e., unique syringe ID, source information, etc.) would be encoded on the RFID tag operating in WORM mode. The production data would be scannable with IntelliFill i.v. scanners, but scanning isolation of a single syringe in the automation deck would not be required. Depending on the capacity of the tag inside the label, potentially more information could be stored directly on the syringe.

Label/tag combinations of this type currently cost approximately $0.60 and would probably not drop below about $0.15 each.

APPLICATIONS TO INVENTORY AND LOGISTICS MANAGEMENT

Another potential benefit from RFID tagging of syringes or labels relates to the ability of RFID scanners to read multiple tags rapidly within its scan range. Potentially, therefore, a scanner connected to an IntelliFill i.v. database could query a refrigerator and report the number and type of syringes located in that refrigerator, and could report any that were expired or due to expire.

With this technology, it is also theoretically possible to:

- Use such a scanner to locate a specific dose or group of doses in a patient care area that are reported as missing
- Log doses out of the pharmacy as they pass through a door on their way to delivery
- Log doses into a patient care location

Use of a tag with the range and power to support these types of applications would probably limit the ability of IntelliFill i.v. to isolate a single syringe within a band of syringes.

APPLICATIONS FOR DRUG ADMINISTRATION

Potentially, RFID tagging overcomes the manual burden associated with barcode scanning at the point of care. An appropriately powered scanner could query tags associated with all doses presented to it and inform the nurse if any of those doses were:

- Incomplete (additional medication was required)
- Expired
- Not intended for this patient
- Early or late

Placing the information currently contained in bar codes within an RFID tag is technically practical.

One can envision a use case in which a syringe or IV bag was tagged with an RFID tag that had large data capacity and could report to a smart infusion pump the verification information required, plus patient-specific instructions to the nurse and programming instructions to the pump such that installation of the dose within the pumping system would automatically configure the smart pump and trigger any of its built-in warnings.

APPLICATIONS TO OTHER DATA RECORDING

A vendor in Australia has created an RFID tag system that will monitor, and periodically record, ambient temperature. Such a tag would permit better controlled reuse of doses returned to the pharmacy, since it could be readily determined whether or not (and possibly for how long) a dose had been stored at an inappropriate temperature for reuse.

CONCLUSION

RFID offers some potential benefits over traditional bar coding and even over multi-dimensional bar code images. The current cost of RFID implementation severely limits those benefits. It is reasonable to believe that the cost of this technology will eventually reach a point where it becomes practical, at least in some environments, although the standards that appear to be driving that price reduction may not support all the features envisioned for the technology.

Baxa Corporation will continue to monitor this technology and consider its inclusion when costs and implementation standards render such inclusion practical.

IntelliFill i.v. is manufactured for Baxa Corporation by FHT, Inc.