Leveraging Radio Frequency Identification (RFID) Technology to Improve Laboratory Information Management

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Technologies for identifying unique items using radio waves, also known as radio frequency identification (RFID), have been available for decades. In the past, the lack of standards and the high cost of tags and readers have limited RFID applications to tracking high-value items. Now that the cost of RFID tags has significantly declined and interoperability standards are being defined, the technology is being applied throughout supply chains. While most supply chain systems are focused on deploying RFID technology on the pallet, case, and carton levels, laboratory information management systems (LIMS) are leveraging RFID data to enhance item (sample) level tracking by creating a location-based, real-time chain-of-custody (COC).

Forensic, clinical trial, and diagnostic laboratories offer an excellent example of a situation in which the COC and integrity of the sample life cycle are crucial. The outcome of a prosecution or diagnostic conclusion depends on thoroughly documenting the movement of samples from one pair of hands to the next. RFID tracking can offer a robust and real-time solution. According to a study by Cap Gemini Ernst & Young, "For an average clinical trial of a drug, applying RFID can speed the trial's completion by up to 5 percent, as well as reduce start-up delays and decrease trial errors and dropouts of trial participants."

This article discusses RFID technology, RFID laboratory applications, and the technique's integration with LIMS. The applied technology is illustrated by STARLIMS RFID integration components (STARLIMS Corp., Hollywood, FL).

RFID technology

A basic RFID system consists of three components: antenna, transceiver (with decoder), and transponder (RF tag). The antenna activates the tag with radio signals in order to read (or write) data and is the conduit between the tag and the transceiver. The transceiver controls the system's data acquisition and communication. The transponder, or tag, carries unique electronically programmed information. RFID tags used for tracking are programmed with a unique set of data (usually 32–128 bits) that cannot be modified.

Often the antenna is packaged with both a transceiver and decoder to operate as a reader that emits radio waves. When an RFID tag passes through the electromagnetic field, it detects the reader's activation signal. The reader decodes the data encoded in the tag's integrated circuit and the data are passed to the host computer for processing.

Hailed by IDC (Framingham, MA) analyst Christopher Boone as "the oldest new technology," RFID technology has been used for years in access cards, livestock tracking, and transponders for automated highway toll collection. What is new and attractive about RFID technology is that the standardization and major reduction in cost are turning it into a highly feasible and advanced alternative to the venerable bar-code solutions.

While bar-code systems use optical signals to transfer information from the printed coded label to the bar-code scanner, RFID uses radio frequency signals to transfer information from the RFID tag attached to the tracked item to the RFID reader located in that vicinity. However, unlike bar-code scanning, RFID reading can be done remotely and does not require direct contact or line of sight between the item and the reader. The reader communicates with a tag that holds digital information (i.e., a unique identification number) programmed on a microchip. The RFID antenna enables the microchip to transmit static and dynamic identification data.
to the reader. The reader converts the radio waves into data, which are passed on to connected information systems. Once the tag’s unique identification number is received, the item carrying the tag can be associated with various dynamic data, such as its origin, expiration date, and storage requirements.

Advances in RFID technology have had a significant impact on the reduction in size and cost of the RFID tags. Also referred to as Smart Labels, these tags resemble typical bar-code labels; under the face sheet of the labels lay RFID inserts that consist of the microchip and an antenna mounted on an ultrathin substrate. Smart Labels can be printed like bar-code labels, employing RFID tag printers capable of simultaneously printing bar code, text, and graphics on the surface of the label and reading, programming, and verifying the RF tag embedded in the label.

Commercial off-the-shelf RFID technology components are available from various vendors such as Intermec Technologies Corp. (Everett, WA), which is offering complete systems comprising tags, inserts, readers, development software, printers, and customized antennas suited for specific system solutions.

RFID tags are very difficult to forge, making this technology very suitable for securing the identity of items. A Food and Drug Administration (FDA) report on combating counterfeit drugs (February 2004) cites RFID as being the “technology with the strongest potential for securing the supply chain.”

**RFID applications in the laboratory**

While most of the emerging RFID business is aimed at large-scale tracking (of container, pallet, and case shipments), the common view is that real growth in the RFID market will not occur until manufacturers are comfortable with tracking individual items.3

Unlike supply chain applications, laboratory applications are already based on testing and tracking unique items (e.g., samples). Agile LIMS vendors are currently leveraging RFID data to enhance sample tracking by creating location-based COC. The use of RFID technology provides laboratories with immediate advantages over traditional identification methods such as bar codes, including enhanced security and the ability to read data without requiring direct line of sight.

RFID is particularly suited for use in applications where a label-based bar code may be contaminated or concealed by environmental or testing conditions. The real justification for RFID comes with demand-
The STARLIMS personalized messaging system (console) displays a dedicated COC events branch (COCEVENT). The number associated with the branch indicates the total number of events logged by STARLIMS within the given laboratory. By double-clicking the branch, it is possible to enter the COC window and review the specifics of each event that took place within the laboratory (Figure 2).

The COC log contains information tracking the previous and current sample locations. The first event is always the arrival of the sample at the first RFID reader. Each additional log entry (record) is the result of two events created by the same sample within the laboratory. In other words, the sample is detected in two locations and the record indicates the move between them. For example, RFID reader #1 may be located at the wet chemistry laboratory and RFID reader #2 at the analytical laboratory. Upon leaving the wet chemistry laboratory, the sample is logged once, and upon entry into the analytical laboratory it is logged again. The first log event is considered as the exit from wet chemistry, and the second as the entry into analytical. When a read/write tag is used, the STARLIMS RFID module can also write these events into the label itself (Figure 3).

Automated tracking using RFID within the laboratory environment is a major advance in maintaining real-time COC of laboratory samples, quality control standards, toxic materials, and other controlled items. The technique is sure to find many more innovative applications within the laboratory as more laboratory automation systems integrate it into their sample life cycles.

**Conclusion**

RFID kits coupled with location-based tracking applications seamlessly integrated into LIMS can detect a sample’s movement and record its COC. This technique is a practical solution for tracing samples from receipt through analysis, through data entry and approvals, up to the final discharge. With Health and Human Services Secretary Tommy Thompson’s call to speed RFID tags’ adoption throughout the medical industry,5 and the ongoing progress in technology, cost reduction, and supporting applications, the future of RFID in mainstream laboratory work flows looks brighter than ever.

**References**

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