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Managing Supply Chain Strategies with Technology www.frontlinetoday.com

Control of the Cold Chain

Systems tap RFID and sensors to deliver greater visibility and improved record-keeping.

BY TOM KEVAN

The stakes in food, pharmaceutical, and chemical cold chains are high. The loss of a trailer of food due to improper handling or transport is measured in hundreds of thousands of dollars; a pharmaceutical shipment, in millions. Because of the financial pressure and increasing regulatory demands for better recordkeeping resulting from the Bioterrorism Act, suppliers and logistics service providers are turning to systems that combine RFID and temperature and humidity sensors.

"The transport segment of the cold chain does not have adequate documentation for the chain of custody of product," says Gene Klein, department manager for supply chain management at Sysco Corp. "In the past, there were only two ways to document the condition of the food. You could go in and check the load, or you could use [a temperature monitoring device] like a Ryan Recorder. Whenever there is a liability claim, there is no way to identify where the problem occurred while the shipment was in transit. Usually, the shipper, carrier, and receiver split the cost three ways."

Addressing the question of documentation, the Food and Drug Administration (FDA) has passed regulations that implement the Bioterrorism Act and impact all players in the food and drug industries. The FDA has mandated that records must identify the previous source and subsequent recipient of food and pharmaceuticals in the U.S. supply chain, along with specific details of the product itself.

Sysco Corp. used Alien Technology's battery-supported semi-passive RFID tags—incorporating temperature sensor and real-time clock—to provide temperature profiles of food shipments.

Infrared data transmitter provided a communications link between Alien's temperature-logging system in the trailer and the PDA's used by Sysco's operations staff.

To meet the need for enhanced cold-chain visibility and better recordkeeping, two providers have produced systems that use radio frequency identification (RFID), sensors, and software, each with a different twist.

Custom Temperature Logging

3PL Solutions and Alien Technology are working with food and foodservice supply distributor Sysco Corp. in a pilot project to develop a custom temperature-logging, RFID-based tag system that has a real-time clock, built-in temperature sensor, and 4 kilobytes of data storage. The system uses a battery-supported, semi-passive RFID tag developed by Alien.

"Measuring the core temperature of products is important," says Mark McDonald, director for product management at Alien. "But these food products are often RFID-unfriendly. If the tag is placed in this type of material, you can't read the tag very far away. So we came up with the tethered concept, where we use a remote temperature probe and locate the RF tag away from the load. The tethered tag gives us the ability to extend the sensor three feet from the tag so that the container can be interrogated at the point of entry into the facility, as opposed to after you

open the door. The connection between the sensor and the tag is hardwired with a bi-directional two-wire bus. You can have multiple sensors attached to the interface."

"As we developed the product, we learned that we should use multiple sensor points," says Rick Clemons, vice president for systems and engineering at 3PL, a solutions provider for third-party logistics companies. "With our system, the shipper can deploy as many sensors as makes sense for a given load. This approach gave us greater insight. During the trials, we found that where the front of the load may be fine, the back of the load was not."

Inexpensive Interrogation

Sysco wanted its operations staff to have an inexpensive way of interrogating a load to determine the condition of the shipment without opening the trailer. "We added an infrared data transmitter—which is what one Palm Pilot uses to talk to another Palm Pilot—for short-range, high-speed transmissions," says McDonald. "This allows a low-cost communications link between the system in the trailer and a hand-held device, such as a PDA, used by operations people before opening the trailer. The tags in this system can be interrogated via a standard reader or the IR data transmitter, or both.

"When a trailer arrives with refrigerated product, you may have a problem in the nose of the trailer and have everything unloaded before you recognize there is a challenge," says Klein of Sysco. "With the PDA application, you can take the PDA and poll the load before you unload the first pallet. And when an incident is recognized, you can e-mail all parties involved."

The system developed for Sysco has two types of reporting mechanism. One involves time-relative data capture. Using this method, the user specifies the time intervals in which readings and reports are made. The second method is event driven, where only changes are registered. "This can be used to record the time the product is at any particular stage of its transport or whether the trailer door has been open," says Clemons of 3PL.

Carrier Performance Check

3PL created software for the system that manages the data collected from the RFID tags and the sensors. It allows Sysco to evaluate how different carriers perform and to identify problems and trends. The software integrates with back-end legacy systems. "This gives Sysco the ability to bring the data in and make correlations," says Clemons.

"The manifest can be downloaded and attached to our existing purchase order, which meets the Bioterrorism Act's record-keeping regulations for transporter and nontransporter," says Klein. "Because we can import this data into our own records, it gives us the ability to slice and dice from a reporting standpoint for carrier, shipper, and product."

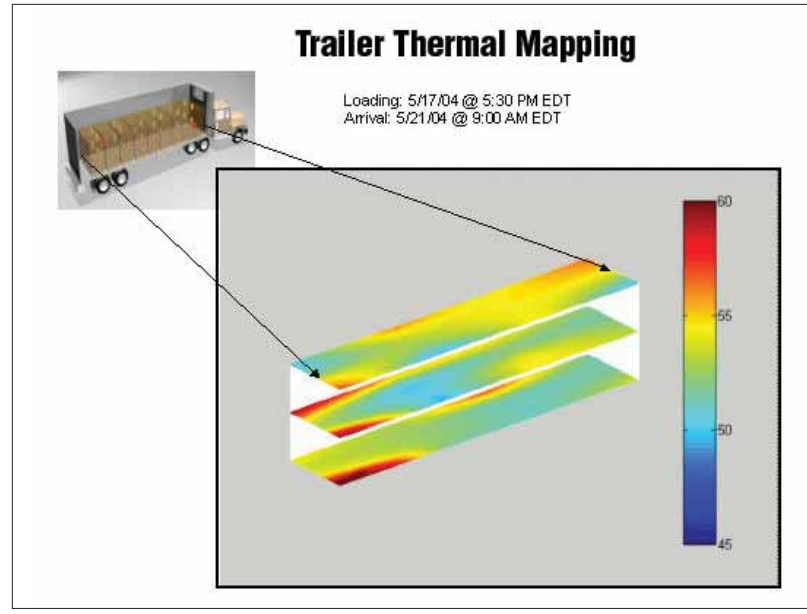
The system also creates an electronic, time-stamped bill of lading, providing an information chain of evidence.

"With the RFID technology that 3PL and Alien brought to the table, we can document the condition of the product from the time it is put on the trailer to the time that it is received," says Klein. "This resolves the issue of the chain of custody while the product is in transport. It can also identify carrier malfunctions such as air leaks or refrigeration problems."

In the Army Now

Alien's semi-passive tags are also being used by the U.S. Army in its combat feeding program.

The Army conducted a large-scale proof-of-principal technical demonstration at its depot in San Joaquin,



Data collected during a thermal mapping study, showing variations from level to level on the load.

Calif., using Alien's semi-passive, sensor-enabled RFID tags to track rations through the supply chain, capture temperature data, and calculate shelf life.

The combat feeding program contracted the Massachusetts Institute of Technology to generate a computer shelf-life model. "We input the data captured from the tag into the computer shelf-life model, and the model manipulates the temperature data and gives us the estimated remaining shelf life for the rations," says chief warrant officer Stephen Moody, coordinator of the RFID program at the Army Soldier System Center in Natick, Mass. "Our operational rations are very much affected by storage temperature. They have a three-year shelf life when stored at 80° Fahrenheit, but if you store them at 100° Fahrenheit, it cuts down the shelf life to six months. The higher the temperature, the shorter the shelf life.

Active Tag for Cold Chain

Another cold-chain management provider combining RFID and sensors is Sensitech Inc. Sensitech has developed a radio-frequency-enabled temperature monitor, called TempTale RF. This monitor records the condition, time, and location of products in near real time. Each unit includes a temperature sensor, radio chip, and antenna. The radio chip falls into the general category of what standards group EPCglobal envisions as Class 4 RFID tags, or an active tag.

"What you add to the tag is not only the ability to identify the item, but also to sense environmental conditions," says Rupert Schmidtberg, chief technology officer at Sensitech. "By RF-enabling these devices, we are making the amount of labor that companies have to expend in handling significantly less. And more importantly, we are enabling a reliable flow of information. You can now aggregate the sensor data … and give companies oversight into their supply chains."

The TempTale monitor from Sensitech includes temperature sensor, radio chip, and antenna.

Class 4 tags are battery powered, incorporate a microprocessor, and can be used in a mesh network. Traditional passive RFID applications, by contrast, include a reader; the only thing a tag can do is respond to a request for information from the reader. In a mesh network, the tags can talk through each other to get to a reader, or the tags can talk to an intermediate called a repeater. This capability lowers the cost of deployment because it requires fewer readers.

TempTale RF's software organizes the cold-chain data in a backend software repository and provides analysis tools based on statistical process methods.

Big-picture View

"Cold-chain management operates at two levels: the transaction level, where you are dealing with individual shipments and trying to react to things in real time, and the more complex level, where you are managing the global supply chain and need a dashboard that gives you feedback in terms of how the company is doing," says Peter Maysek, vice president for RFID solutions and business development at Sensitech. "Strategically, you need a way to look at your supply chain in aggregate and to determine how the company is [performing] against its operating standards. That is where you bring in the statistical methods, where on one page you can get a global view of a complex supply chain and start to look at things like problem areas."

Manufacturers of pharmaceuticals and vaccines are audited by the FDA, which requires documentation that products have been kept within an acceptable temperature range. Manufacturers need hard data to show the FDA that they are in control of their products.

"They also use the data to improve the efficiency of their supply chains," says Maysek. "If they find there has been a small amount of out-of-range temperature that has accrued, but has not yet damaged the product, having the ability to react before they lose the load is important. Many times the value of the load is very high. Where a truckload of food may be worth $20,000 to $50,000, a truckload of bulk vaccine is tens of millions of dollars."

These systems can also help track thermal shelf life. **" Some pharmaceuti-**

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For further reading on this and related topics, see these articles, available at www.frontlinetoday.com/102003links:

"Theft and Terror Threats Push Sensors into Supply Chain"
September 2004

"FDA Issues Final Rule on Food Traceability"
December 2004

cal companies have said that they could increase their yield significantly by knowing exactly how much time the product has spent in less-than-perfectly refrigerated conditions. The RF capability will help them do that," Schmidtberg says.

Active vs. Passive

There are three reasons to choose battery-assisted passive tags over active tags. Semi-passive tags are stealthy. They do not beacon their identity. They are less complex and less expensive than active tags, though the addition of batteries and data storage to Alien's tags are closing the cost gap. And battery life is enhanced by frugal operating parameters.

"By being passive, the Alien-3PL system does not let anyone on the outside know that it is there," says Klein of Sysco. And if someone does crack the container, the system detects the incident based on a change in the temperature and records the event."

Active tags typically have an operating range greater than 100 feet. As a result, they require fewer readers, which reduces the cost of deployment. In addition, active tags do not require intervention of a reader to pass on their data. So they are more proactive in transmitting their data, which allows staffs managing cold-chain operations to respond more quickly to detrimental conditions. FS

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