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Temperature Management and the Cold Supply Chain

Improving Quality, Shelf-life and Revenues with Pallet-level Monitoring of Fresh Produce

Introduction

Cold chain optimization for perishable foods is becoming increasingly important. According to a recent study by the United Nations Environment Program (UNEP)¹, over half of the food produced globally is lost, wasted or discarded as a result of inefficiency in the human-managed food chain. The UNEP study reported that *up to one-quarter of all fresh fruits and vegetables in the United States are lost (wasted) between the field and the table*. Another study done by the University of Florida Food Distribution and Retailing Resource Center identified that *one-third of shipped produce is wasted annually, amounting to a loss of \$35 billion each year*. Half of that waste is a result of temperature problems experienced between the grower and the retailer – totaling over \$17 billion a year. Successfully reducing this shrink has a direct benefit to the bottom line. Using strawberries as an example, one grocery chain estimated that reducing shrink in strawberries by just 1% would add more than \$1.1 million of profit to their bottom line annually.

Specific Example: Impact to Bottom Line for a Commodity (Strawberries):

1% reduction in Shrink	Increase in profit of \$1,173,555
6% reduction in Shrink	Increase in profit of \$7,378,830

Proper temperature monitoring and management throughout the cold chain is no longer a luxury but a necessity. Even relatively small variations in temperature can significantly impact the shelf life of fresh produce – and its value. Certain types of produce are more susceptible than others. Berries, cherries and mushrooms, for example, are extremely temperature sensitive. In the example illustrated below produced by the University of Florida, strawberries should be shipped at a consistent temperature of 34° Fahrenheit. A temperature drop of 2° will freeze and destroy the berries resulting in a complete loss of product. Shipping at an average temperature of just 42° (an increase of only 8°), shaves seven days off the shelf life, significantly impacting quality and potential revenues. Temperature monitoring throughout the cold chain – and providing the ability to act on changes in temperature in real-time – enables documented delivery quality and increased customer satisfaction.

Cold Chain: Strawberries	
Transport time to a distribution center	2.5 days
If maintained at a consistent 34°	10 day shelf life
↓ If 2°	freeze damage, complete loss
↑ If 4°	Lose about 3 days of shelf life
↑ If 8°	lose about 7 days of shelf life

The path between harvest and retailer for perishable produce involves many steps and handoffs. To maximize quality, value and shelf life, it's essential that temperature is monitored and managed throughout the cold chain.

Cold Chain Handoffs:

- Field to warehouse/packer – via truck
- Warehouse to distributor – via truck, plane, train
- Distributor to wholesaler – via truck, plane, train
- Wholesaler to retailer – via truck
- Retail loading dock to shelf

At each point along the way, there's potential for trouble. Produce could wait in the field, or sit in the sun on a loading dock, or be stored in a truck with broken or uneven refrigeration. Each handoff also creates the opportunity to break the chain of responsibility. Without pallet-level temperature monitoring and logging, the warehouse can claim that the produce was fine when it left, for example, leaving the distributor wondering about the quality and remaining shelf life. Ultimately, the retail grocer is left making a determination on the quality and can accept or reject a shipment – or re-estimate its value – with limited or inaccurate information.

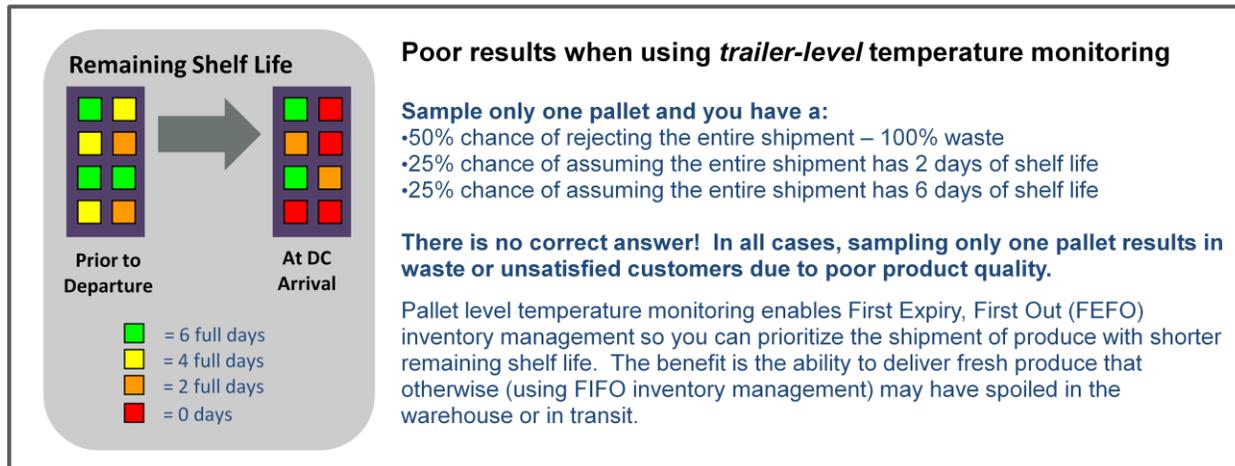
The Need for Pallet Level Monitoring

Approximately 1.1 billion pallets of produce are shipped annually to retail grocers in North America and Europe – but how can you track 1.1 billion pallets of produce cost-effectively? This problem isn't new to anyone but, without a viable method for addressing the previously cited \$17 billion waste problem, the costs are passed through the cold chain.

The growers are often left holding the bag – a bag that is filled with the spoiled fruits and vegetables. The cold chain has tried to address this problem by implementing temperature monitoring solutions at various points along the way, such as environmental monitoring of the tractor trailer or the cold storage facility. However, this does not accurately track the condition of each pallet of produce, leading to inaccurate assumptions that group the condition of an entire shipment when it is known that the cooling (and quality) is not uniform. This leads to unnecessary waste and “finger pointing” in assessing liability.



For example, some members of the cold chain are implementing temperature monitoring solutions at the “truck level” by putting one or two temperature monitoring tags in the refrigerated trailer with the produce. While this provides some information on temperature control, it's hardly adequate for monitoring the condition of each pallet of produce as temperatures within the trailers can vary significantly. Trailer-level monitoring doesn't account for the fact that the remaining shelf life of produce varies at the pallet level. What's needed is pallet-level temperature monitoring from harvest through to retail delivery.



The above diagram illuminates the benefits of pallet-level monitoring and how it enables a FEFO (First Expiry, First Out) model over the more traditional FIFO (First In, First Out) approach by factoring in the variation of pallet-level temperatures within a refrigerated trailer and its impact on the remaining shelf life of produce. FEFO-based inventory management means you ship out the product with the first expiry date first, regardless of when it was received in the warehouse.

The color codes indicate the remaining available shelf life of pallets in a trailer in a shipment from a grower to a retail distribution center. In the diagram on the left (prior to shipment), it indicates that two pallets (in orange) have only two remaining days of shelf life prior to departure, three (in yellow) have four days of remaining shelf life and three (in green) have six days of remaining shelf life. With this information, the distributor can choose to ship those with six days of shelf life (green) to more distant retailers and those with only two days of remaining shelf life to a location with rapid or same day consumption (such as a cafeteria). With pallet-level temperature monitoring, these FEFO-based decisions can be made at the warehouse – or other steps in the cold chain – at a pallet-by-pallet level and result in maximizing shelf life and improving cold chain yield.

Non-uniform ripening is a fact within the perishable cold chain. While there may be a number of contributing factors, a significant cause is due to temperature variations within the trailer. Note in the example above that the impact on shelf life is not uniform. That is, there is not necessarily a consistent ripening between each pallet. As such, a single “read” or assumption on the entire trailer shipment will be wrong for many of the individual pallets.

If the temperature is monitored only at the trailer level, the potential exists for poor decision making that can have very expensive consequences. As discussed in the example above, when the trailer arrives at the distribution center, only one pallet may be selected and sampled for quality. If a red pallet were chosen, the entire load may be rejected and wasted when, in fact, only half of the load should be wasted. Conversely, if a green pallet were chosen for the

sample, the entire load may be accepted meaning that four pallets of poor quality produce will be delivered to stores or customers. In this example, in each case, trailer-level monitoring produces incorrect – and costly – results.

As a result, by implementing pallet-level temperature monitoring and FEFO inventory management, produce revenues can be improved by maximizing the available shelf life based on the dynamic state of the produce by knowing its temperature throughout the distribution process. What's important for maximizing the delivered value of the produce is knowing the current remaining shelf life from the field to the retailer. This level of knowledge is what drives effective real-time decision making, shrink reduction and quality improvement.

There are additional costs that result from poor quality besides the cost of the wasted produce itself. Brand equity can suffer as consumers shy away from particular brands or grocers due to a poor experience. If a consumer favors a particular store for its produce but finds that the produce spoils the day after they purchase it, they may switch stores.

There's also a cost associated with being out-of-stock on a particular item. If a grocer rejects an entire shipment of produce because it has unknown or questionable quality, they miss the sales opportunity until replenishment, which may be days away.

From Grower to Grocer

Several companies are working to provide a more complete method of tracking the temperature of produce in-pallet throughout the cold chain. These companies are utilizing state-of-the-art wireless RFID solutions that enable them to place cost-effective and reusable Intellex temperature monitoring tags *within the packed produce at the pallet level* to monitor its temperature from field to store with little or no change to existing processes. The Intellex tags can be read while packed within the pallet of produce making this solution easy to implement.



Intellex Temperature Monitoring Tags in pallets of bell peppers

In Canada, Clifford Produce is a leading producer and packer of locally hot-house grown vegetables. As they represent a number of growers, it's essential that they are able to manage and track produce from each grower as it comes into their warehouse. Using software from ProWare coupled with Intellex temperature monitoring tags, Clifford is tracking the pallet-level temperature of the produce as it comes in from the growers and is graded and organized in their warehouse while awaiting shipment to distributors and wholesalers.

By placing the tags directly in with the produce, Clifford can log the produce's temperature from the point of harvest into the warehouse and onto the truck. In addition, the RFID tags store

location and product information providing an attached and documented record for each pallet. Clifford uses an Intellex reader in each cold storage room to provide real-time inventory of the pallets of produce within their warehouse.

The results have exceeded expectations. Currently, Clifford is removing the tags as they load outbound trailers then recycling the tags back to the growers for the next harvest. However, Clifford soon expects that the tags will be shipped with the produce as it leaves the warehouse, transferring relevant data with the produce through to the next step in the cold chain and all the way through to the retailer.

On the island of Oahu, Armstrong Produce is working with the Hawaii Department of Agriculture to optimize the cold chain from the warehouse to the retailers. Hawaii is heavily dependent on agriculture – both locally grown as well as imported. However, due to the tropical Hawaiian climate, spoilage due to temperature exposure is a significant problem, especially when shipping produce from island to island, or receiving produce from the mainland or Asia. Once the produce leaves the Armstrong warehouse, it can be subject to damaging temperatures inside a truck or sitting on the hot tarmac at the airport waiting for the air carrier to load it and transport it. Temperatures inside the produce can quickly reach the ambient air temperature or higher – drastically reducing the shelf life.



Air Freight is a Critical Component of the Cold Chain in Hawaii

Together with Asia Pallet Pooling and Intellex, Armstrong Produce and the Hawaii Department of Agriculture are working to monitor and log the pallet-level temperature data from the warehouse, on board the trucks, at the airports and through to the distribution centers on other islands – providing accountability and control throughout the entire process.

Accountability and Quality Control

These two projects demonstrate the benefits of monitoring the temperature from grower to grocer. Temperature monitoring tags can be placed with the produce at the time of harvest and accessed throughout the distribution process providing invaluable temperature data. The grower, transporter and grocer can make more informed decisions and better manage their inventory to maximize the produce shelf life. They can also look at the historical temperature data to determine if systematic breaks in the cold chain exist and how best to correct them. This not only helps manage the quality and shelf life of the produce but also helps optimize the cold chain and drive down costs.

The Intellex temperature tags also log waypoint data. Every time the tag is read, location information can be recorded to further enhance accountability. This data is extremely helpful in optimizing cold chain operations.

Real-time Decision Making

Utilizing machine-to-machine (M2M) technology adds even more value. M2M facilitates getting the pallet-level produce temperature monitoring data into the hands of decision makers on-demand – in near real-time. By linking RFID temperature sensor tags to the Internet via cellular backhaul, automated or person-guided decisions can be made that further enhance cold chain optimization.

For example, consider a shipment of strawberries heading from California's Salinas Valley to Chicago by truck. In-pallet temperature monitor tags can be set to monitor the product temperature of each pallet every 15 minutes (for example). If an alert is noted in central Nevada due to a 4° rise in the temperature of some of the pallets, that information is read and then sent, via cellular backhaul, to the distributor who can recalculate the shelf life and instruct the driver of the truck to divert the shipment to Salt Lake City to deliver produce with sufficient remaining shelf life and maximize the value of the strawberries.



Making It All Work

Pallet-level temperature monitoring will drive improvement in the cold chain. Affordable, reusable temperature monitoring tags that can be read without unpacking the pallets or containers is what makes pallet-level monitoring possible. Because the tags can be read when placed within the produce on the pallets, no changes to produce handling are necessary. Because the tags feature on-board memory, they can store thousands of temperature data measurements – as well as waypoint and other data – that can quickly be accessed and used as the basis for real-time acceptance criteria or shipping prioritization based on FEFO inventory management.

The result is a system where decision making can be made on demand, in real-time, to maximize shelf life, improve quality and value and increase revenues.

¹<http://www.ens-newswire.com/ens/feb2009/2009-02-17-01.asp>

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