Automated Temperature Monitoring

Considerations for the Retail and Foodservice Industry

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Refrigeration Monitoring
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How is automated digital storage temperature monitoring different from traditional paper-based temperature monitoring? The short answer to this question is that digital sensor technology enables operations to have real-time (24/7/365) visibility of cold storage with automated alerts. Still, there is more to it than that, so let's discuss the details and decisions to be made. What do the regulators require for documentation and action in the event of temperature issues? Is there scientific guidance for the food safety professional?

Retail Food Store Deli	Non-Existant FSMS	Well-Developed FSMS
Average # of out of compliance items	4.6	2.4

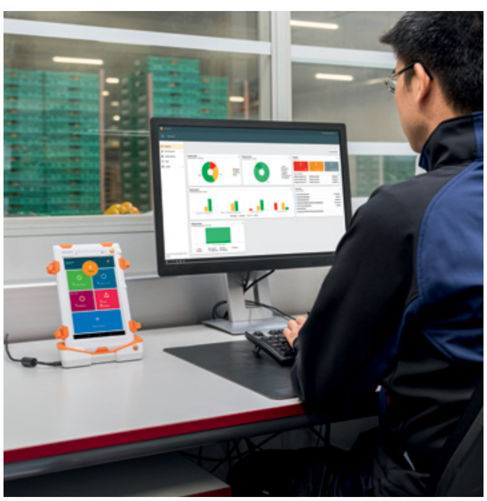
*Factsheet: The Occurrence of Foodborne Illness Risk Factors in Retail Food Store Delis 2015-2016

Fast Food Restaurants	Non-Existant FSMS	Well-Developed FSMS
Average # of out of compliance items	4.5	1.7
Full-Service Restaurants	**Non-Existant FSMS**	**Well-Developed FSMS**
Average # of out of compliance items	5.8	2.1

*Factsheet: The Occurrence of Foodborne Illness Risk Factors in Fast Food and Full-Service Restaurants 2013-2014

Recently published results called out in The FDA Risk Factor Study Factsheet identifies that establishments *"with well-developed FSMS had almost half as many risk factors and food safety practices that were out of compliance than those with non-existent FSMS."* The data also identifies "the highest out-of-compliance foodborne illness risk factor was improper holding time/temperature," as called out on the recently published "Call to Action for Regulators." Food safety professionals are seeking new ways to support efforts in bending the curve of foodborne illness. Both regulatory and industry are looking to learn how technology can play a role in delivering this objective. One specific area of interest is automated temperature monitoring.

As the industry shifts from manual record collection to automated storage temperature monitoring, there is a gap in science-based guidance on setting up appropriate monitoring programs. These systems provide the ability to continuously collect multiple data points (air temperature, simulated product temperature, door openings) of real-time conditions. They also provide automated alert notices to employees when potential unsafe conditions require action. These new inputs require a different management

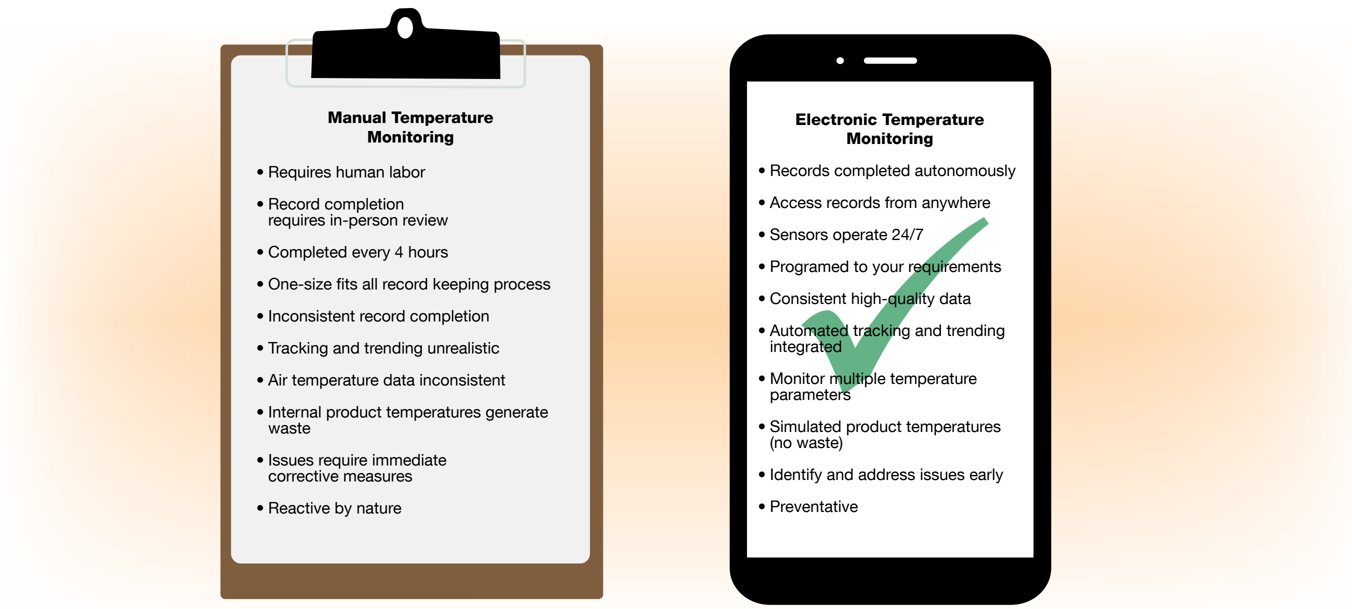


methodology around what conditions warrant immediate actions. Managers must now determine how often to collect temperature data from hot and cold storage units. They must also define a meaningful period of time when temperature has fluctuated outside of expectations enough to trigger an alarm to employees who must take corrective action steps before stored products could cause food safety concerns or be subject to loss based on FDA food safety requirements.

The food safety professional must consider numerous factors when developing their organization's policies and procedures for food safety, data collection, record keeping and corrective actions. Studies and regulatory guidance resources exist for most food safety situations, but little guidance is available on properly managing refrigerated storage temperatures at the retail foodservice operations level. One of the few commonly used industry resources is found in the FDA document Managing Food Safety: A Manual for the Voluntary Use of HACCP Principles for Operators of

Food Service and Retail Establishments. The manual generally directs the operator to set refrigeration temperatures “Lower than what is required by regulations” and is supported by “frequent monitoring” to detect any potentially hazardous conditions. This results in operators going through a trial-and-error process to properly establish and set refrigerated storage temperature(s) several degrees lower than the desired holding point of at least 41°F (5°C). It also established a general rule of thumb that has evolved in foodservice to have refrigerated storage area air temperatures checked every 4 hours and documented on paper-based, manual records (or logs). Doing this provides an operator the opportunity to detect air temperature fluctuations during regular monitoring activities.

How does electronic monitoring stack up against the status quo?



When converting to an automated digital temperature monitoring system, the food safety professional will have to make several new decisions regarding timing for data collection and corrective actions. This visibility allows for a more preventative approach to managing refrigerated storage and requires changes to be made to storage temperature processes, procedures, and corrective actions. The configuration and programming of the system are important to ensure meaningful data is collected and analysis of that data is put into place. This requires a new mindset around how the system is programmed to send ‘meaningful’ automatic alarm notifications that trigger a corrective action process to be taken. In a paper-based system, taking swift and immediate action to high-temperature readings makes sense because it has typically been 4-hours since the previous reading and products may have been exposed to unsafe conditions above 41F° (5C°). However, with an automated temperature data logger checking temperatures every 15 minutes, at what point should the system be programmed to make you aware of a potential issue and, more importantly, of a condition that requires immediate action?

Is there any science that the food safety person can use as guidance for establishing this new temperature monitoring process to justify alarm settings across a business?

It turns out that in 2010 the National Institutes of Standards and Technology (NIST) conducted research and published a paper on the impact of temperature changes on products held in refrigerators equipped with automated temperature measurement equipment. The observations and findings from this study show great potential for use in the retail foodservice industry as general guidance. The results also suggest a need for additional research in this area to support more clear scientific evidence about automated temperature monitoring systems and how they provide more value than traditional paper-based temperature monitoring practices (Chojnacky et al., 2010).

The study found that air temperature changes faster than products that have thermal mass. The authors go on to state that “it is clear that choosing the right thermometer and correctly positioning it inside the refrigerator is critical to obtaining meaningful temperature monitoring data... A thermometer with a thermal mass similar to a stored <product> can be used as an effective tool for determining <product> temperature” (Chojnacky et al., 2010, pp. 17). When installing temperature data loggers in refrigerators, do not simply use an air probe to collect data. Use an air probe that is ‘buffered’ from the swift changes in air temperatures to match the actual change more closely in the products being monitored.

Interestingly, NIST observed one probe in the study that reported consistently lower temperatures than anticipated. The specific temperatures on average and at specific points in time, are lower than all of the other probes by sometimes 2°F (-17°C) – 4°F (-33°C). It was observed that “During the door-opening trials, the repeated influx of room temperature air likely caused the refrigerator to pump out additional cold air to compensate. This would, in turn, drive the temperatures of the shelf and the sensors near the vent down even lower (than all the other temperatures). Our data support this explanation, as the lowest temperatures recorded at any point in the study were measured by the same probe during the door opening trials” (Chojnacky et al., 2010, pp. 17-18). When installing temperature data loggers, it is important to observe where the air circulation vents are located and place the data logger away from these vents, more in the center area of the storage unit.

Time after power-off until vial temperature exceeded 8 °C

Name and Location	High Density Mixed (h:min)	Medium Density Mixed (h:min)
vial 20 (in tray, lower shelf)	1:14	0:45
vial 13 (syringe in box - top)	1:12	0:50
vial 11 (inside original packaging)	1:40	1:01
vial 10 (inside original packaging)	1:50	0:58
vial 6 (inside box, floor level)	2:10	1:15
vial 12 (inside cardboard box	2:19	1:46

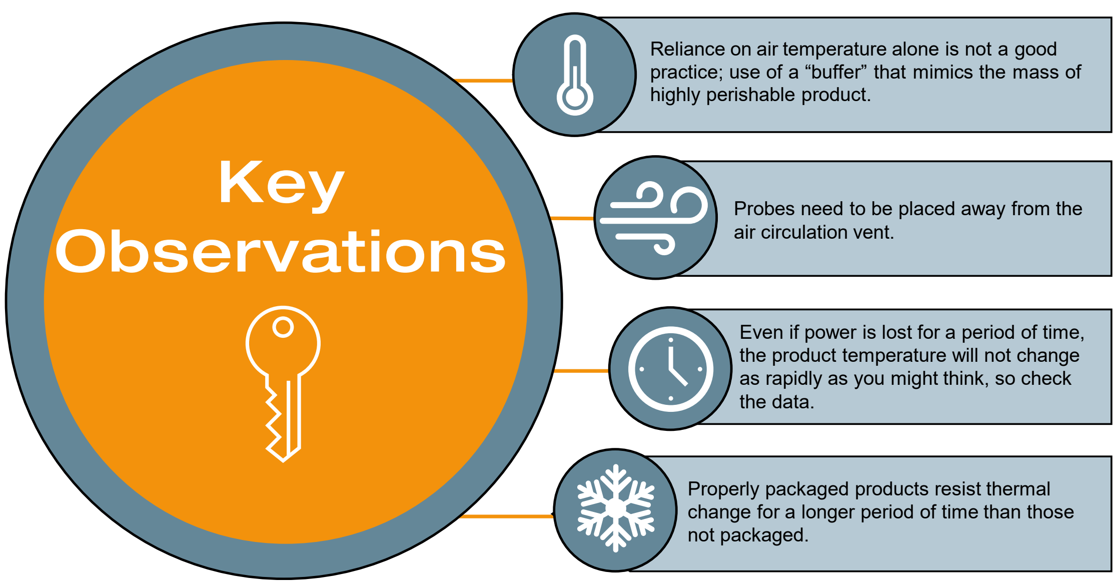
*Chojnacky et al., 2010, pp. 44 (Table 11)

NIST turned off the power to the refrigerator to see how quickly the products inside would rise in temperature beyond the safety level and all the way to equal the temperature in the room. The study observed solid door refrigerators and glass door refrigerators. Products in the glass door refrigerators increase in temperature more rapidly than those in solid door refrigerators, proving that the thermal transfer through glass is faster than the transfer through solid/insulated doors. The study went further to report how quickly employees would have to respond to an issue to protect the products in storage.   NIST observed that “all of the <products> exceeded 46.4°F (8°C) in less than 2.5 hours, and in some cases, less than 1 hour…The doors of the… refrigerator model used in our tests were the sliding glass variety…a major known drawback to the glass doors is that they lack the insulation provided by a standard…door" (Chojnacky et al., 2010, pp. 45). However, they point out that managing inventory through the glass door has many advantages, including keeping the doors closed during normal operation. NIST further points out that many businesses operate on a 24/7 basis where employees can take action before inventories can be harmed if the power is lost. Lastly, they point out that the density of the products in storage impact the speed of the temperature change. Many of the consumables monitored for food safety have considerable product mass, which will slow the rate of temperature change. When setting alarms for storage units monitored by temperature data loggers, the food safety professional must look at the results of the NIST study and consider the type of food in the storage unit and FDA guidance. For example, seafood must be held at more strict temperature limits than cheese, soft drinks, or other perishables. The NIST study does help set a standard for waiting at least 1 hour and possibly 2 hours (depending on the density of the product) before triggering an alarm because even in the event of a total power failure (the worst-case situation), product temperatures do not rise above the high-end refrigeration levels that quickly.

The last decision the food safety professional must make when using automated temperature data loggers is how often to collect temperature data. Here NIST does not make any observations or statements. Yet, we can rely on two ideas that should provide guidance.

- First, if the shortest alarm is 1 hour above or below temperature expectations, the data logger must record temperatures more often than once per hour.
- Second, to ensure that the alarm is meaningful (and not just a one-time observation), the data should show a certain 'string of continuous readings' outside the expectations.
  The scientific community typically defines three separate observations to be enough to determine a meaningful trend has occurred.

If a data logger is programmed to read temperatures at 15-minute intervals and to alarm/alert employees of an issue after four consecutive observations, then the process is reporting a trend that could impact the product and the food safety protocol negatively. The NIST study points out a few critical observations that all food safety professionals should consider when managing the change from paper-based, manual food safety logs to automated temperature data loggers.



When converting to an automated temperature monitoring system, food safety professional leave the reactive paper-based process behind and gain access to enterprise-wide real-time temperature control visibility. This is accomplished using stationary wireless data loggers paired with cloud computing analytics software. The system can be programmed to meet specific refrigeration requirements. Once the system is set up, the food safety professional gains access to 24/7 real-time visibility of storage temperatures, automated warnings, and alert notifications. This change in the monitoring process also enables a shift in perspective and management of how refrigerated storage temperature areas are managed. In addition to eliminating human error during the monitoring, recording, and analysis of the ambient air temperature in refrigerators, the system should provide data relative to the internal product temperature by using a product simulator and monitor how often and how long a door is open. With all of these continuous measurement points (air, product, door), the food safety professional provides the organization with data to prevent temperature-related food safety issues rather than only reacting to them. These parameters layered together enable a risk-based approach to temperature monitoring rather than one that is purely reactive.

References

Chojnacky, Michal & Miller, Wyatt & Ripple, Dean & Strouse, Gregory. (2010). Thermal Analysis of Refrigeration Systems Used for Vaccine Storage.

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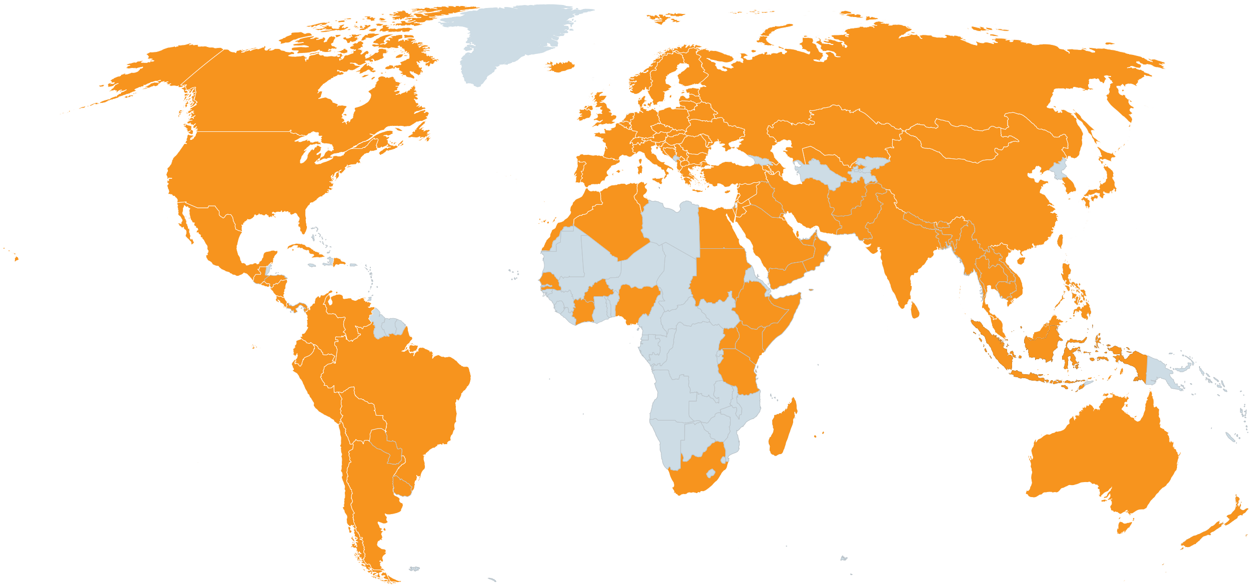

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