Low-cost, easy-to-install wireless sensors are becoming standard practice when it comes to remotely monitoring temperatures in refrigeration equipment such as walk-in coolers and freezers, cold rooms, beverage coolers, cold tables and more. Such sensor systems can be retrofitted to existing equipment or used with new equipment to monitor temperature, humidity, vibration and other conditions. By collecting and analyzing temperature data, wireless sensor systems can help manufacturers, maintenance service providers and their customers save money, work more efficiently, improve product quality, and promote safety on the job.

For equipment manufacturers and service providers, remote sensor systems can also open a new revenue stream based on installation, remote equipment monitoring and troubleshooting, and predictive maintenance. This article covers some of the components of a typical remote refrigeration sensor system, describes how they work together and some system-use cases.

**Sensor components**

Installing remote wireless sensors in walk-in coolers, freezers and other refrigeration equipment is quick and straightforward. Typically, there are three standard components that make up a remote wireless sensor solution, which include: sensors, gateways and online cloud accounts.

**Sensors**—The sensors themselves are matchbox-sized devices with long-life and replaceable batteries of approximately 1–5 years. The small size of the sensors allows them to fit into spaces where wired sensors and larger devices might not work. Each sensor can be mounted with screws or heavy-duty adhesive. Because there are no wires or cables required, the installation is simple. Setting up a single-sensor system takes just a few minutes, and a system with dozens or hundreds of sensors can be set up in a few hours.

For refrigeration equipment, temperature and humidity sensors should be installed inside the temperature-controlled area. If the cooler or case is large, multiple sensors in different spots can detect variations in temperature and humidity. For those that want to monitor the equipment’s mechanical operation, vibration sensors placed near the compressor and the evaporator and condenser fans can show if these components are operating within the acceptable vibration range. Companies can also include door sensors to indicate when cooler doors are left open for extended periods, as well as wireless cameras to monitor activity in and around coolers.

**Gateway**—The gateway is a small network device that connects to a local WiFi or Ethernet network. In some cases, the gateway may connect to a cellular network when used with delivery vehicles, etc. The gateway is responsible for wirelessly capturing measurement readings from the sensors and transmitting these readings up to an online cloud account. Both the gateway and sensors have tiny embedded radios that communicate with each other using either sub GHz RF communication or Bluetooth Low Energy (BLE) signals.

During setup, the gateway syncs automatically with the sensors and does not require manual configuration of each sensor. To
prevent interception during transmissions, the gateway commonly protects the sensor data with strong encryption using SSL AES-256.

It should be noted that wireless sensor networks are also an option for refrigerated trailers, to ensure the quality and safety of temperature-sensitive shipments like food and pharmaceuticals in transit. A mobile sensor setup includes wireless sensors in the trailer that stream data to a mobile data gateway up front that’s plugged into the truck’s power supply. A typical mobile gateway sends its data securely to the cloud via cellular signals and includes GPS, so dispatchers and managers can monitor real-time location as well as temperature, humidity and other conditions inside the refrigerated unit.

**Online Cloud Account**—The temperature and humidity readings coming from the sensors are accessible to authorized users through a password-protected online cloud account. The cloud account is just a website that authorized users can access that allows them to see their current sensor readings as well as historical data by each sensor. In addition, admin users can set up temperature monitoring ranges (also called thresholds), configure notifications, manage users, set blackout windows, and download reports.

The secure, online cloud account provided by the sensor vendor relieves the installer and the end user of the responsibility for setting up, maintaining, and securing an on-premises file server to store the sensor data. The value of the online cloud account is that it aggregates all the temperature data into easy to understand information. In one central location, all the temperature measurements are available for review that can be accessed by phone, desktop computer, laptop, iPad, etc.

For example, shift managers and the chef can all view temperatures for their assigned restaurant while the general and maintenance managers can login and see the temperatures for multiple restaurants. Service companies can login and see all of their customer temperatures for all locations if provided such access. A service agreement between the end user and the sensor network installer—a cooler manufacturer or service company—could also allow the installer’s service team to monitor the equipment remotely. This usually comes in the form of a monthly subscription or yearly cloud access license.

Ideally, the online cloud account will present the data from the cloud in visual format so that managers and technicians can see at a glance if conditions are in the correct range. Over time, users can chart historical data to see if there are specific times of day, days of the week or seasons when conditions are more likely to be out of range. By setting temperature and humidity parameters for each sensor, users can also set up alerts that they receive when conditions are out of the acceptable range. For example, a cafeteria manager might request alerts when the walk-in-freezer door is left open for more than 30 seconds.

**How sensors help save**

These monitoring and analysis capabilities can benefit refrigeration technicians, their employers and original equipment manufacturers. Following are a few of the savings that are possible.

**Time**—When repair services have access to a customer’s sensor cloud account, they can minimize the time they spend in potentially crowded places like restaurant kitchens where physical distancing is not possible. For example, if a customer is having trouble with a cooler operating out of range, the technician may be able to remotely diagnose the issue or rule out some possibilities by reviewing the sensor data trends for that piece of equipment.

**Remote Diagnostics**—Remote troubleshooting can help the tech select the right parts and tools before making a service call. It also keeps them from spending any more time than they need to at the customer’s site, by allowing for diagnostics ahead of time. In some
cases, the technician may be able to talk the customer through a simple adjustment that solves the problem without a service call. For example, a cooler that’s consistently out of range first thing in the morning may not have a mechanical problem—it may be that someone on the early shift is leaving it open too long while they gather ingredients.

Faster resolution time—Troubleshooting before a service call and eliminating the need for some service calls can also help repair services operate more efficiently. Simple problems that can be resolved remotely, and service calls that are expedited by pre-call diagnostics, free up technicians to move on to other tickets faster.

Identification of unknown issues—One of the primary benefits of sensor systems is that they can detect problems that often go unnoticed. Often unknown temperature spikes after hours over the weekend can now be discovered and fixed by service companies.

End-user benefits
In addition to the time and money that sensors can provide contractors, technicians and OEMs, end users can additionally benefit. Following are just some of the ways sensors can help:

Eliminates need for manual temp checks—Remote monitoring also helps end users save time and money. One immediate impact is that wireless data logging frees employees from having to manually check and record cooler and freezer temperatures several times a day for safety and compliance. Trading manual checks for remote monitoring can save as much as $600 per restaurant per year1 in employee time.

Solve a small problem before it becomes a large problem—Because the sensor system can send alerts when a piece of equipment is operating outside its safe range, food and pharma manufacturers and foodservice businesses can react quickly in case of a major equipment problem. For example, if a cooler fails in the middle of the night when no one’s in the building, the problem might not be discovered until the next morning. By that time, hundreds or thousands of dollars’ worth of products in the cooler may be unusable, and the day’s work schedule may be disrupted as well.

However, when the cooler has a sensor system that sends an alert when the temperature rises above the safe range, the end user is notified in real time. That allows them to call for an emergency repair or move the cooler’s contents so that the inventory stays safe and the next day’s work proceeds as planned.

Compliance Reports—Managers can generate reports that show equipment temperatures and other trends over time, which saves time on compliance reporting to local and state regulators. A database showing equipment function can also help businesses demonstrate compliance with federal food safety guidelines such as the Food Safety Modernization Act (FSMA)2 and Hazard Analysis Critical Control Point (HACCP)3 management system.

Brand Reputation and Protection—Better temperature and humidity compliance supported by real-time data, can also help food producers and foodservice businesses avoid the costs associated with foodborne illness outbreaks. The financial consequences can include fines and litigation, lost business, brand damage that raises marketing and customer acquisition costs and expenses associated with investigating and remediating the source of the outbreak. This is a widespread problem: The U.S. Centers for Disease Control (CDC) estimates that 48 million Americans get a foodborne illness each year, with 128,000 hospitalizations and 3,000 deaths.4

Reduces Stress and Anxiety—Remote temperature monitoring systems help reduce stress for owners and operators. Having an automated system in place to spot outages and temp spikes ensures that problems will be caught before financial losses are incurred.

New Revenue Streams
Besides the safety and efficiency improvements that a wireless sensor system can deliver, sensor installation and monitoring can also open new revenue streams for original equipment manufacturers and for companies that service commercial refrigeration equipment.
Equipment manufacturers who add sensors to their products before shipment can offer remote monitoring and diagnostics services to customers as a subscription plan or as part of the equipment purchase price. Service providers can offer to retrofit customers’ existing refrigeration equipment with sensors and offer remote monitoring packages, which can strengthen customer loyalty and repeat business.

These monitoring options can improve customer experience by reducing the time it takes to troubleshoot equipment and resolving some issues remotely without a service call. Remote monitoring can also alert customer service representatives or technicians as soon as a customer’s equipment develops problems, so they can start troubleshooting right away, rather than waiting for the customer to discover a problem.

With a large and detailed enough dataset on the equipment being monitored, analytics can help manufacturers and service providers offer predictive maintenance, which saves them and their customers time and money. Predictive maintenance can reduce unplanned downtime and prolong the life of equipment by addressing problems early, before they become major, costly repairs. It can also reduce maintenance costs by as much as 12% compared to preventive maintenance—and as much as 40% compared to reactive maintenance.

Conclusion
The technology that underpins these gains in safety, efficiency and cost management is readily available and easy to deploy. Manufacturers and service providers that adopt remote sensor technology now for commercial refrigeration equipment can help their customers navigate a difficult economy when every advantage counts. In this way, remote sensor technology allows service providers and equipment manufacturers to take on the role of partner with the customers they serve, while making their own operations more efficient, more cost-effective and ultimately more profitable.

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References