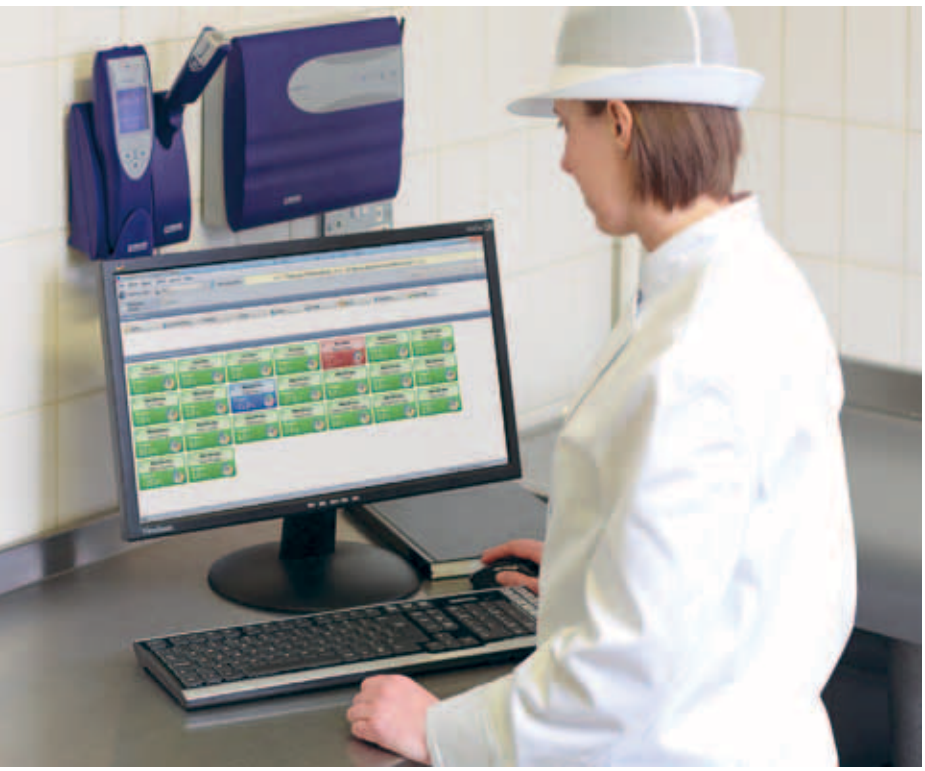
Electronic Paper-free Temperature Monitoring

By Tim Gamble

Making compliance simple, robust and cost effective for everyone, not just the big boys.



An operator checks the live temperature view on a wireless monitoring system.

We all know the seriousness of a food borne illness event. The costs to a foodservice operator in terms of human suffering caused, legal defence against prosecution, damage to valuable brands and consequent disaster recovery PR campaigns can be immense. Best practice automated temperature monitoring systems can significantly reinforce even the best food safety systems, bringing far greater assurance that such an event will not occur. If it does, they can provide solid evidence at law, eliminating doubts that might be cast on hand written charts. They can save money too, by reducing the team workload, helping to avoid a costly food loss, and highlighting plant faults before they become expensive repairs.

It is often thought that automated systems are only of value to large organisations with sophisticated production facilities and large numbers of cold rooms, fridges and freezers. The fact is that today's technology makes affordable solutions available to even the smallest operator. They range from using smart phones and other handheld devices, to installing wireless networks that can gather site wide information. Multi-site solutions for chains such as quick service restaurants, pubs and sandwich bars are also available via internet or intranet.

Item to be recorded	Paper Example	Best handheld methods (no typing)
The CCP (The record sheet header)	Goods Inwards	Scan bar code or RFID tag mounted in area; or enter password
Time & Date	10:30am 15/12/2012	Generated by the handheld
Supplier	ABC Butchers	Scroll select from list
The Food Item	Fresh Chicken	Scroll select from list or scan barcode (if available)
Temperature (As probed)	10°C	Read via wireless or cable connection to probe
Traceability (Unique reference number)	#145	Generated by device
Corrective Action (Decision on the food)	Delivery refused	Scroll select from list
Accountability (Who did the check)	Signature	Scan personal RFID tag or card with printed barcode
Preventative Action (Record in diary)	Re-assess supplier	Usually entered into terminal at daily review

Table comparing manual paper chart methods with using a hand held device.

Need for temperature history records

Compliance, across the EU and much of the world, is based on the HACCP food safety model. The two fundamental legs of HACCP are temperature control (to kill bacteria or prevent its growth) and hygiene practices (to detect or prevent contamination). Of these, temperature control is by far the most demanding in terms of routine monitoring and recording, day in day out.

Temperature control begins at the back door and ends with service to the customer. In between there are two key temperature requirements. Firstly, food must be stored within safe temperature limits. Secondly, it must be processed to achieve safe temperature limits. The steps at which this is done are Critical Control Points (CCPs). Historical records must be kept to verify these temperatures.

Storage temperatures need to be recorded two or three times daily. Process temperatures should be recorded for each identifiable batch of food. Both sets of records should accurately show what was checked, where it was checked, when it was checked, and who checked it. In other words they must have integrity, traceability and accountability.

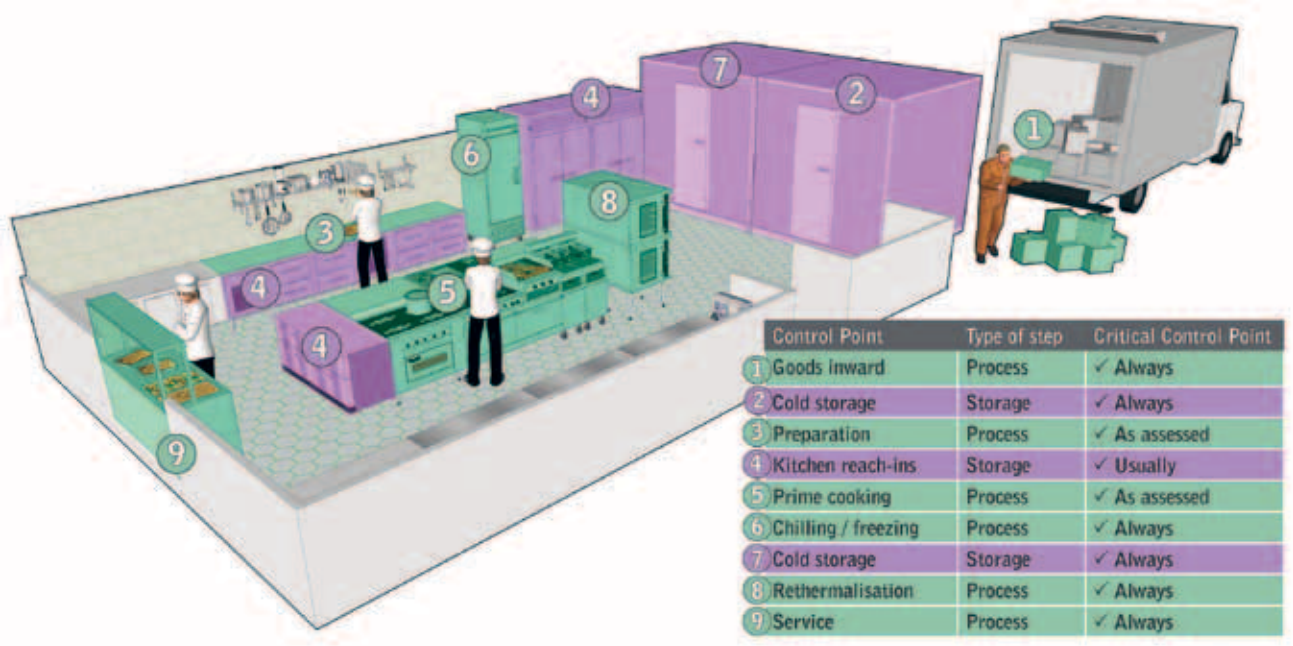
Food safety is proactive. Recording time and temperature on a chart can be self incriminating if 'Corrective Action' is not taken and recorded when a breach of safe temperature limits arises. Corrective actions ensure that food which may have become unsafe does not reach the customer. Possible corrective actions include destroying the food, returning it to the supplier, using it within a safe timeframe, moving it to a safe environment and so on, according to risk and circumstances. Good solutions empower front line staff to take the appropriate actions quickly and effectively.

Also important are 'Preventative Actions'. These are more considered initiatives to proactively prevent re-occurrence of the breach. Possible preventative actions include organising repairs to refrigeration, re-training staff on the correct loading of fridges, reviewing instructions on re-heating food, and so on. Preventative actions are best decided daily or at other regular intervals during a review of critical events that have occurred.

Automated systems comprise integrated hardware, firmware and software solutions that make dealing with all these challenges and disciplines simple to execute for all members of the foodservice team.

Available automatic methods

Process temperature monitoring can, in most cases, be conducted efficiently and effectively by checking food samples using a handheld data collection device in conjunction with a wireless or cable (plug-in) linked probe. This is an audit process proving that target temperatures have been



A typical kitchen layout showing food storage and process Critical Control Points.

maintained or achieved during the process. Some items of process equipment such as combination ovens, blast chillers and re-thermalisation carts will have integrated methods for data collection and reporting. This data is extremely valuable for demonstrating that temperatures have been safely managed during the process.

While such data can usually be relied upon day to day, a check of the product at the end of cooking, chilling or rethermalising will confirm that the manufacturer's controls are continuing to deliver the end results that they are actually reporting, and will integrate these end temperatures into the overall temperature monitoring system.

Storage temperature monitoring is again an audit process to ensure that refrigeration and other storage control systems are maintaining the required food temperatures over time. It can be achieved using one of three alternative methods, or a combination of them. Firstly, food samples or simulants stored within appliances can be physically probed using handheld devices; secondly, data can be physically collected from data loggers installed in them; or thirdly, data can be centrally collected on a continuous basis via wireless networks.

The remainder of this article looks at how these methods might be employed.

Process temperature monitoring using hand probing and logging

Traditional paper based solutions involve probing samples of each batch of food at the end of each process with a digital thermometer and then transcribing the temperature, along with other relevant information, on to a pre-designed paper chart. As already mentioned automated solutions for this purpose are based around handheld devices used with a wireless or cable linked probe. The devices might be PDAs, smart phones or tablet computers or alternatively, they might be hand readers specifically designed for the kitchen. Temperatures are logged automatically in the handheld. Related traceability and accountability data (CCP location, batch number, the operator taking the reading, etc.) can be input automatically by scanning a bar code or an RFID tag, by scroll-selecting from a pre-established list, or by free typing (best avoided for control and efficiency reasons). Time and date will be maintained within the device.

Once collected the data can be transferred to a central temperature monitoring database via a variety of methods including GSM, Wi-Fi or docking cradle.

When selecting a handheld device not specifically designed for the kitchen a number of factors need to be considered. It should be ensured that they are built to hygienically safe standards. They should not have exposed grooves, recharge ports, USB ports or other orifices that constitute food traps. They should survive drop tests and should have limited alternative uses to avoid pilferage. Industrially built PDA's with protective hygienic membrane covers tend to qualify better in this regard. Sim-

plicity, speed and accuracy of use, and security of data are further aspects to consider. Wireless connections from handheld to probe tend to be more hygienic and less damage prone than cable connections and give greater flexibility of use.

Storage temperature monitoring using hand probing and logging

Handheld devices and probes can likewise be used to collect all the necessary data from cold rooms, reach-in fridges and freezers and other storage appliances in the same way and using the same principles as described above for collecting process temperatures. This makes an automated HACCP compliant total temperature solution available to even the smallest operator at a relatively modest cost.

Good practice requires that the temperature of a food sample or a pack of food simulant gel within each storage appliance is physically sampled and recorded at least twice daily. With manual systems, a common but dangerous short cut is simply to read and write down the air temperature shown on an appliance's digital display. This may be very different from the food temperature. This is because the air sensor involved is generally installed next to the evaporator to manage the cycling of the refrigeration plant. If a fridge or cold room is overloaded and air circulation is restricted, the food in the body of the storage space could be at a significantly high temperature. The mass of the food will, in any event, move more slowly in temperature than that of the refrigerated air.

There is often a temptation to fudge hand written records if the task is forgotten or overlooked under the pressure of meeting production or service targets. This leaves the data open to question. Use of a handheld device with RFID location tagging or barcode proves that the appliances were actually visited at the time shown on the records. This rightly ensures the task is given high priority as part of daily routines.

Storage temperature monitoring using data loggers

Data loggers represent an alternative method for monitoring storage temperatures. These are mounted within the appliance amongst the food, out of the airflow. They log temperatures continuously at regular intervals.

A hand reader being used for checking a process temperature with a wireless probe

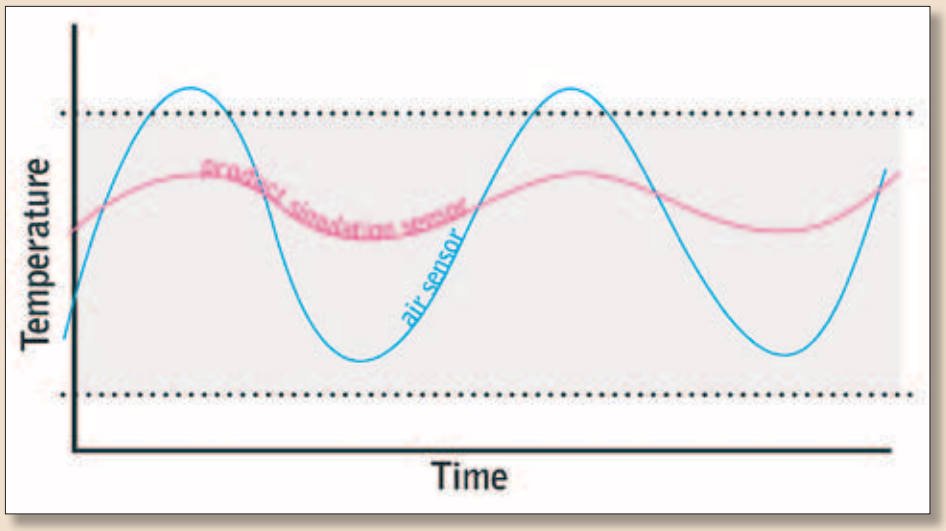
It is preferable to select loggers that can be permanently mountable in the appliance and read with a handheld, tablet or computer for download to the temperature monitoring database. Ideally, the data collection device should be brought to the logger for download, not vice versa. If loggers are loose on a shelf there is always the doubt that they might not have been left in the specific appliance to which they are assigned. Loggers that can be read by a handheld device over a wireless link rather than by cable connection will streamline the data collection process.

The advantage of loggers over handheld probing is that they generally carry alert lights to indicate a breach of temperature limits, alerting the operator to the fact that an event has occurred between visits to the appliance. The data, once collected, will indicate the extent of the breach in both time and temperature. This helps with determining the appropriate corrective action. It can often help avoid the extreme corrective action of wasting the stored food.

Loggers also enable the temperature profile of the appliance to be presented graphically, highlighting any plant performance issues such as excessive compressor cycling or unnecessarily low average temperatures causing plant wear and energy wastage. This is important for determining preventative actions.

About automated food simulation

Food simulation should be based on documented research such as G Tucker: 'Guidelines for the use of Thermal Simulation Systems in the Chilled food Industry' Campden & Chorleywood food research Association, January 1995. This looks at cooling curve characteristics of a variety of packs and sizes of different foodstuffs. It can be achieved by embedding the sensor in a simulant compound supplemented where necessary with a suitable damping algorithm.



Storage temperature monitoring using a wireless network

Wireless temperature monitoring involves creating a wireless network of critical cold rooms and appliances, so that data is brought back continuously and without human intervention to a central monitoring base station.

Wireless provides all the benefits of data logging without the need to visit each appliance twice daily. Typically a large site with around 80 cold rooms and appliances could save one full time equivalent. Having said this, less frequent and less time consuming routine visits are always necessary, at intervals determined by risk, to check cleanliness, product expiry dates and product condition (cooked not stored with raw and so on).

A cold room full of food can be extremely valuable, and food loss can disrupt service significantly.

Wireless temperature monitoring depends on temperature sensors and transmitters installed in each appliance. The sensor should be placed amongst the food, out of the airflow, as for data loggers. Paralleling the concept of probing a simulant gel, it is essential that it should transmit a simulated food temperature, not the air temperature that fluctuates according to circumstances. Both loggers and sensors that perform this function are available.

A highly valuable feature of wireless monitoring is that alerts can be raised and propagated as and when temperature breaches occur. This enables prompt corrective action to save the food by moving it to an alternative storage location. A cold room full of food can be extremely valuable, and food loss can disrupt service significantly.

When selecting a system, the effectiveness of the alert management features should be carefully considered. Options for propagating the alert can include monitor screen pop ups, email messages, SMS text messages and electronic message boards placed strategically in the kitchen. The software should have options to allow only those authorised to deal with alerts to do so, and for escalation of messages to go to more senior team members if they are not dealt with promptly. Features that 'block out' nuisance alerts can also be important, otherwise credibility is lost and problems might get ignored (the 'cry wolf' syndrome). Most important amongst these features are time delays after a limit is breached. Without time delays temporary aberrations, for example during heavy usage periods when fridge doors are constantly opening and closing, will create repetitive nuisance alerts. Lock outs during defrost are also valuable for cold rooms, as are lock outs for appliances only used during busy periods. Out of use periods are best identified by centrally monitoring whether or not the appliances are powered up, but they can also be managed by scheduling 'in use' meal periods on the software.

Certain systems come with diagnostics options over and above those available from data logging. These can also help with determining preventative actions. Door open monitoring on cold rooms can estab-

Technology	Compliance	Frequency	Benefits	Weaknesses
Generic 'Radio' or 'Wireless' one-to-one network	MPT1340 license exempt and similar	433mHz 458mHz	Good potential range. Low cost. Widely used RF solution for many applications	Used by multiple devices and systems so can be interference prone. Generic nature of this band makes performance very specific to each manufacturer's implementation. Generally uses a 'one-to one' wireless link to base station, not 'mesh'
ZigBee® Mesh	IEE 802.15.4	2.4 Ghz	Proprietary, robust, selfhealing 'mesh' network. Harmonised to co-exist with other IEEE 802 series technologies (Bluetooth, Wi-Fi) without interference	Initial network set up can be more technical for larger systems
Wi-Fi	IEEE 802.11	2.4 Ghz	Widely recognised and accepted for IT purposes. Infrastructure will often already exist on site.	Unpredictable performance in kitchen environment. May raise network security concerns with IT.

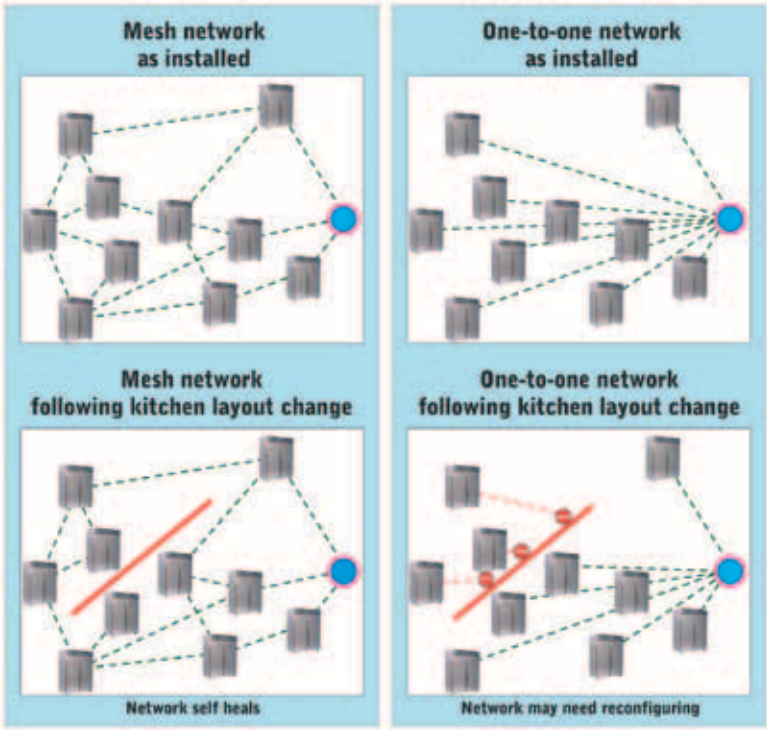
lish if staff need re-educating on the need to keep them closed (it can also be used to detect pilferage if doors are opened out of hours). Compressors, valves, fans and gas leaks can be monitored to see if refrigeration maintenance is required. Humidity can be monitored to detect the likelihood of moist air entering the room, then condensing and freezing on evaporators reducing their effectiveness.

Care should be taken ensuring data security and protection. Systems should back up data at the base station. They should not deliver data direct to a host PC unless it is always turned on or to a network which could suffer downtime. Reports should be encrypted or protected to prevent the possibility of tampering.

There are a number of wireless technologies available, and their strengths and weaknesses are assessed in the above table.

Environments such as kitchens containing lots of stainless steel can deflect signals, so that black out areas can develop and change somewhat unpredictably within the kitchen, particularly if appliances are re-positioned or barriers are created. ZigBee 'mesh' networks are specifically designed to be 'self healing' in this circumstance. The transmitter/receivers in each appliance relay data from one to the next across a wireless grid. Any data which cannot find a direct route to the base station due to distance or black spot is automatically routed through one or more other appliances on this grid. This route will change in response to black spots or interference developing, hence healing the disrupted network. By contrast, most generic open access networks are 'one-to-one', with each appliance transmitting direct to the base station. These are best installed with a number of strategically located sub base stations or signal repeaters in anticipation of possible kitchen layout changes or other interference.

The illustration above compares the possible loss of signal from certain appliances resulting from a 'black spot' created by a newly established barrier of stainless steel on a one-to one wireless network, with the continuity provided in this same circumstance by a self healing mesh network.



Top: Table comparing technologies for wireless temperature monitoring

Under: Wireless self-healing mesh networks versus traditional one-to-one technology

Solutions for multiple outlets and multiple sites

An important consideration in selecting an overall food storage and processing solution is whether it allows the various methods (probing, logging and wireless) to be mixed and matched from a single database. For example a hospital with a central kitchen and satellite ward kitchens could use wireless monitoring for the central facility and handhelds at ward level, where data loggers could be installed in the fridges or freezers. The same handhelds could be used for checking food from re-thermalisation carts or ovens at service. Data would then be brought back to a central database over the hospital intranet. This will enable site wide reporting of temperature histories, breaches and corrective actions, with daily senior level sign off of a single 'critical events log' designating any appropriate preventative actions.

Multi-site solutions are also available for chains such as quick service restaurants, pubs, and sandwich bars utilising client intranets. These enable data to be

viewed and stored centrally and securely for the entire enterprise. They can also ensure enterprise conformity of critical limits, alert time delays and other set up parameters. Access to this data by central food safety and IT support teams, internal and external auditors, refrigeration contractors and other stakeholders can deliver high value results that deliver substantial cost savings while increasing protection of customers, reputations and brands.

Bringing it all together

Handheld solutions can fully replace paper trail systems to provide electronic automated temperature monitoring solutions to HACCP requirements for food, both while stored or in process. They can deliver robust, more dependable temperature history data with full integrity accountability and traceability. They can save time and greatly facilitate decision making on corrective actions for front line staff. They can do this cost effectively for the smallest of operators.

Introducing data loggers instead of food or simulant probing can automate storage temperature monitoring further, enabling more informed and potentially less costly corrective actions to be taken. Loggers can save more time and can introduce diagnostics to help decide on the most appropriate preventative actions. Loggers are still a very affordable solution for smaller operators, particularly if they can be read by the same handheld device used for probing food at process CCPs.

Employing wireless networked monitoring for food storage temperatures enables the propagation of real time alerts which in turn facilitates prompt corrective actions to save costly food before it's too late. It saves a significant amount of time visiting appliances. It can also provide detailed diagnostic information in respect of poor staff practices and refrigeration plant malfunction, leading to important preventative actions such as staff re-training, maintenance to refrigeration plant and supplier re-assessments.

Areas and sites can be linked together across an intranet to provide easy data access for designated stakeholders. This can be for audit, system support, and maintenance purposes. Multi-site solutions can also include secure centralised off site data back up and storage.

In summary, automated electronic solutions can be tailored to all situations, protecting customers and eliminating reliance on error-prone and sometimes forgotten or fudged hand-written records. They offer a robust due diligence defence at law, and a reliable information base for disaster recovery PR campaigns. Time can be saved collecting data, and money can be saved from averted stock losses, pre-emptive plant maintenance and reduced energy consumption. Last but not least, trees and vital storage space can be saved as well!

Tim Gamble is founder, Chairman and Managing Director of Monika. He has represented Allied Members on the UK and Ireland, EAME and Worldwide Executives and Boards. He can be reached at tgamble@monika.com.