Logger Logistics

When it comes to transporting products with a demand for high control specifications, Dave Ayres at Calibration Services provides some pointers on how to choose the right temperature logger

Dave Ayres obtained his BSc (Hons) in Physics from the University of London in 1974, followed by research in co-sputtered films of PTFE and carbon. He was employed by the CEGB where he developed computer-controlled calibration methods for various devices. He patented a fluidised calibration furnace and in 1986 he joined Isotech as Deputy Head of the UKAS Laboratory. He left in 2001 to set-up Calibration Services (Calserv) Ltd, which specialises in the calibration of critical instruments, as well the development of new methods and products.

A data logger is an electronic recording instrument that monitors and reports various changes in environmental conditions over time. Data loggers can measure temperature, relative humidity, light intensity, voltage, pressure and shock, among other factors. Because they are stand-alone devices, data loggers are convenient to use in order to verify and control the quality of handling of any given product in storage, transit or distribution; and as they do not need to be linked to an external source of power, they can travel alongside a product while continuously recording the specific types of data that are required. Today, data loggers exist in a multitude of shapes and sizes, and are used everywhere from local businesses to the International Space Station.

To meet the growing demand for optimal cold chain management and the need for small data recording instruments, engineers have developed miniaturised, battery-powered data loggers equipped with a microprocessor, data storage system and sensor. Some data loggers provide the recorded data on a paper strip chart, while others can interface with a personal computer. Information can be simply downloaded, either by connecting the logger to a computer port and using specialised software to analyse, organise and print the data; or, in the case of wireless data loggers, by gaining remote access to the information. With wireless data loggers, you can monitor several locations at the same time, creating the equivalent of a data logging network.

Since data loggers monitor and record the environmental conditions of sensitive products in storage, transit and/or distribution, their use enables better control of cold chain quality. More specifically, data loggers provide the crucial information needed to ensure the safe handling, transport and storage of your products, and ascertain whether or not they have been kept in ideal conditions.

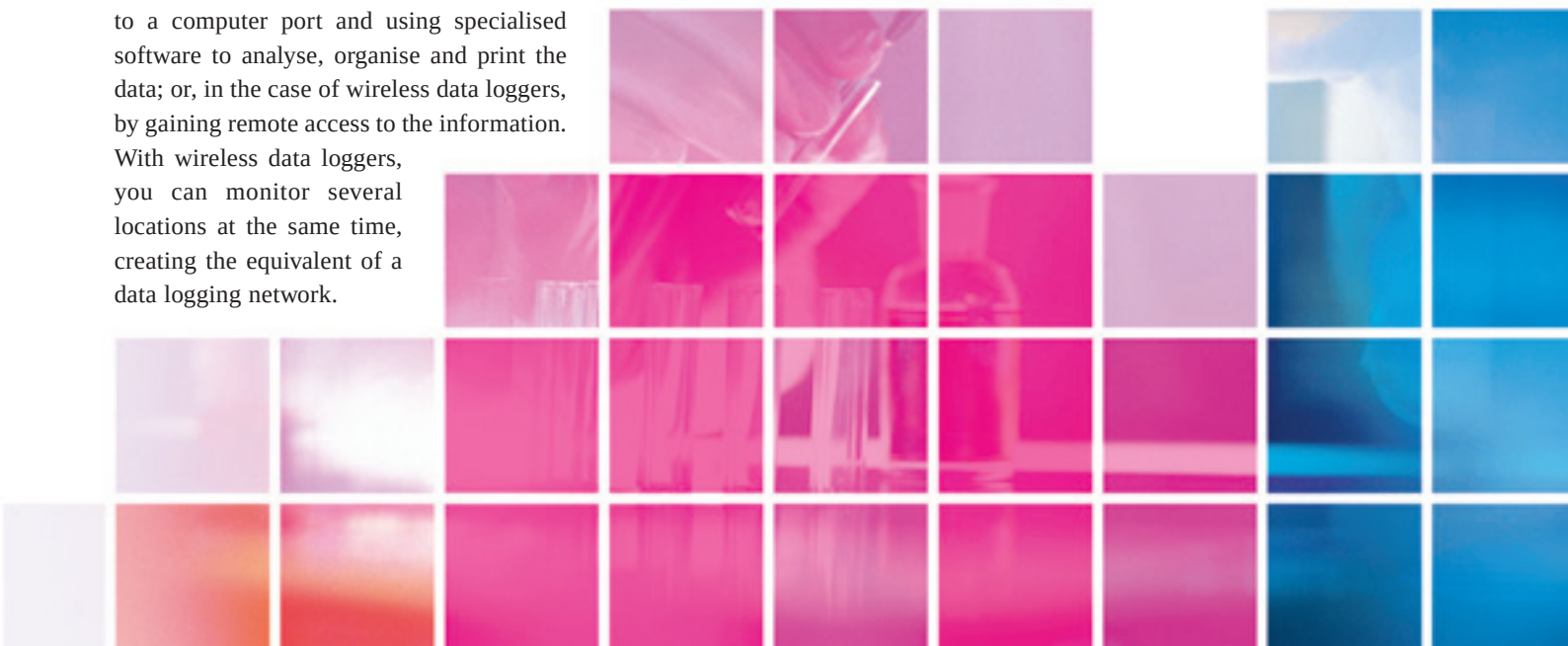

Figure 1: Logger with external sensor

Figure 2: Loggers with an internal sensor

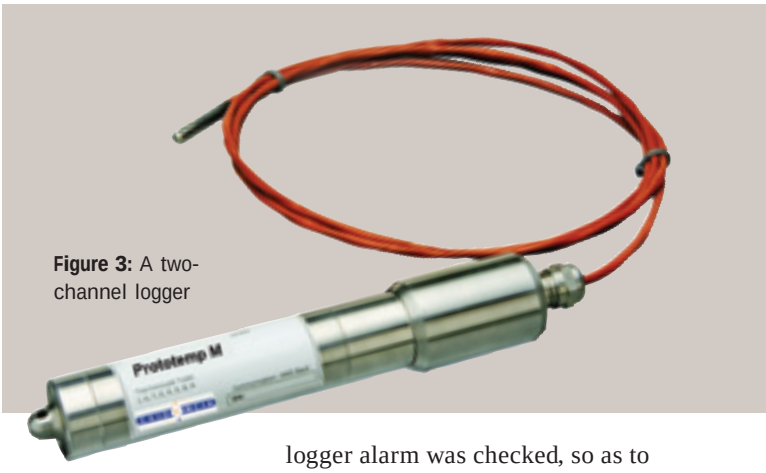

Figure 3: A two-channel logger

EXTERNAL OR INTERNAL

Temperature loggers have the sensor either outside the case that holds the electronics, or inside the case. Figure 1 shows a plastic-cased logger with an external sensor, and Figure 2 shows two robust metal-cased loggers of different sizes that have internal sensors. See 'Advantages and disadvantages of external and internal sensors.'

Loggers are available that have internal and external sensors, allowing two temperatures to be measured simultaneously (such as when monitoring the temperatures in a fridge that has a freezer compartment). Figure 3 shows a two-channel logger.

ADDITIONAL FEATURES

Some loggers can indicate an operator-set alarm condition, often via red and green LEDs in the unit. The alarm can also be complemented by an 'event' button which, when pressed, causes the logger to note the time it was operated. The logging of the button press is intended to show when the logger alarm was checked, so as to prove that operator checks are being carried out on the alarm status on a regular basis as is required in the storage of food or blood. Figure 4 shows a logger with alarm status LEDs and an event button.

Figure 4: Logger with alarm indication and event status button

Figure 5: Remotely readable waterproof logger

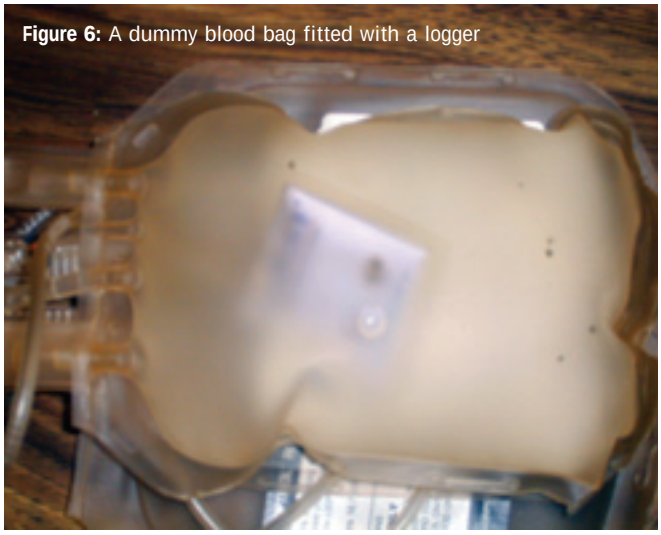

Figure 6: A dummy blood bag fitted with a logger

Figure 7: Wireless data download

Legislation such as that governing the storage of blood requires the blood temperature to be monitored in a specific way in order to reflect its true temperature history. Loggers that are waterproof and can be read remotely using wireless technology can be placed into dummy loads – such as a blood bag containing a saline solution – to give near-perfect results. Another advantage of this method is that the logger is less likely to be stolen, as it does not look attractive and needs specialist equipment to read it. Figure 5 shows the size that such loggers can be, and Figure 6 shows an example of a dummy blood-with-logger bag ready for use.

Low-cost wireless loggers enable logged data to be downloaded without the packaging being disturbed. This can save time and effort by reducing the possibility of rejections, and lessening the risk of contamination or having to repackage for onward transportation. Figure 7 shows a wireless reader downloading data from a logger placed inside the box.

Downloading data to a computer is normally performed via a lead, docking station or by using wirelessly. The software used to read and interpret the logged data can be provided with the logger or purchased separately, potentially making what seems like a low-cost logger expensive in real terms. Software is usually configured to allow the data to be presented in various ways, including the use of graphs, tables and statistics. Examples are shown in Figure 8 (see page 92).

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Advantages and disadvantages of external and internal sensors

Advantages of external sensors

- A wider operating temperature than the logger electronics, giving a potential range of around -200 to +1700°C using an appropriate sensor
- Fast response, whereas a sensor inside the case holding the electronics will have a relatively slow response time
- Precise positioning: the sensor can be placed exactly where the required temperature is to be measured
- Remote sensing: the sensor can be placed far from the electronics.
- Easier calibration: it is easier to calibrate this type of logger as only the sensor has to be placed into the controlled calibration temperature, rather than the whole logger. This makes this type of logger potentially more accurate, depending on the performance of the logger's electronics
- Real-time monitoring: in many cases the logger can be read whilst measuring, rather than downloading the data at a later date
- Multiple inputs: multiple sensors can be connected to the logger, enabling the temperatures across large volumes to be monitored by a single logger (for example in a warehouse)

Disadvantages of external sensors

- Interference: the sensor's cable may pick up electrical interference
- Requires a lead-through: if the sensor is monitoring temperatures inside a chamber then the cable may have to be routed to the logger that is mounted outside. This will require some type of lead-through in the chamber wall
- Complex calibration: if the logger and its sensor are located in the same environment that is to be measured, then the calibration should replicate this – hence requiring both the logger and sensor to be in the controlled calibration temperature
- Damage to the cable or sensor can be sustained by having them exposed to the environment
- Wrong sensor: it is possible for the sensor to be changed and therefore degrade the logger's performance or invalidate the calibration

Advantages of internal sensors

- In-process monitoring: the complete logger can be immersed in the environment that is to be monitored
- Immunity: loggers can be made to withstand harsh environments.
- No lead-throughs: the logger can be placed inside a sealed chamber such as an autoclave
- Positioning: loggers can be easily positioned where the temperature is to be monitored, such as in a fridge with shelves
- Slow time response: the logged date may better show the temperature of interest such as that of a stored product in a fridge when the door is opened momentarily

Disadvantages of internal sensors

- Slow time response: the logged temperature may not show fast transients accurately such as in a fast heating process
- Lower accuracy is possible because the electronics have to operate over a wide temperature range and the whole unit needs to be calibrated in the calibration temperature
- Limited temperature range: the current models can only cover a range of about -80 to +150°C using different models

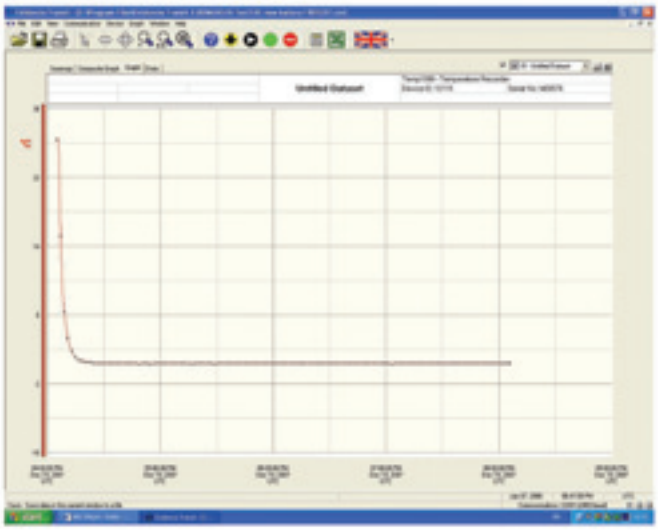
When transporting logged temperature products over large distances and to numerous locations, problems may be encountered due to the receiver of the goods not being able to read the logger if they do not have the correct equipment or software. A new model is now available whereby the logger is plugged into a computer's USB port and downloads the data as a secure PDF that can be emailed and digitally stored.

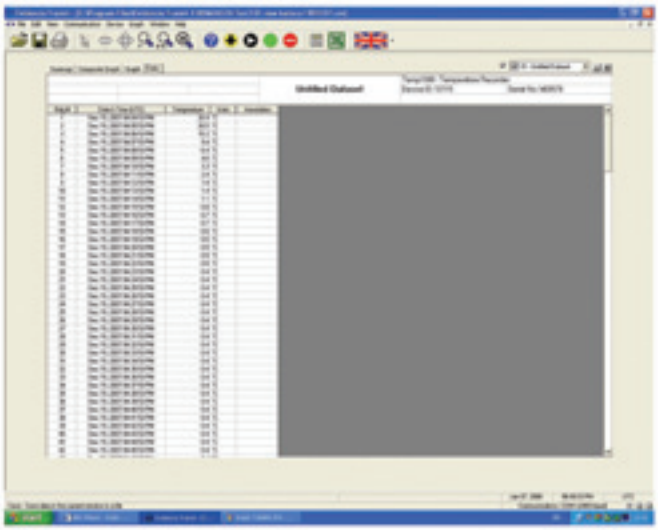
Many loggers have a life of about 400 working days and are therefore disposable. Long-life loggers normally require their battery to be replaced at some point – ensuring that the battery is in good condition prior to a monitoring period is essential. Generally, the higher-priced loggers have battery life indicators and others have recommendations for the average life of a battery. It is essential that any new replacement battery is capable of operating over the temperature range of the logger, especially if it has an internal sensor and is operating at high temperatures.

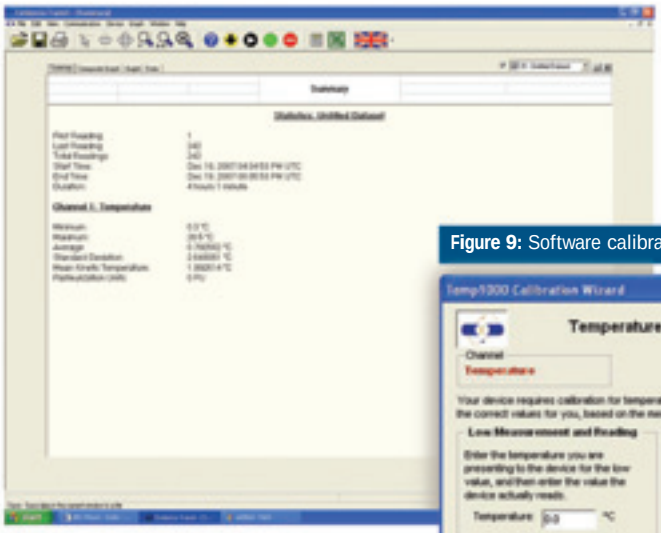
CALIBRATION

The calibration of loggers is a point that is often overlooked. The consequences of logged

Figure 8: Examples of software options







temperatures being out of tolerance should be stringently evaluated; in a worst-case scenario, a dispute could end up in court and cases have been lost in the past as a results of calibration weakness.

Loggers are made to a particular specification which must be studied carefully to ensure it meets the user's requirements. To verify the specification and potentially improve on it, the logger should be properly calibrated, especially if there is significant value attached to the results stored in the logger. Calibration by a laboratory accredited for loggers by organisations such as UKAS is recommended. Any laboratory performing the calibration must provide complete traceability in terms of both temperature and time in order to be able to issue a valid certificate. Some loggers enable the inherent errors to be minimised using off-sets programmed into the logger. Figure 9 shows a screen print for making a simple calibration adjustment to a logger.

Figure 9: Software calibration adjustment to a logger

Easy calibration of a logger by any competent calibration facility is preferable for world-wide use and for keeping operating costs low. Ease of calibration and suitable temperature range should always be considered when deciding on the most suitable logger.

Generally speaking, the more you pay for a logger, the better it is; but because they are developing so fast this price/performance ratio is falling. The most accurate stand-alone loggers are capable of uncertainties of the order of ± 0.1°C over a temperature range of around -20°C to +100°C, a rate rising to ± 0.5°C for the majority of models that cover this range. An accuracy value of ± 0.5°C is often specified in testing of heated chambers or in the transportation and storage of temperature sensitive goods, so using a logger with an accuracy specification of ± 0.5°C may be somewhat risky. Again, the potential consequences of an inaccurate reading must be properly taken into account.

CONCLUSION

Data loggers are becoming smaller and cheaper to produce, so they may tend to become disposable items that could be built into the product or packaging. As loggers used for monitoring the temperature of goods in transport are becoming ever cheaper, it is both advisable and practicable to use at least two spaced loggers in each shipment. The results from each logger should agree to within a specified tolerance; if they do not, this could either be due to a fault within a logger, or to the shipment's temperature not being isothermal. The loggers could then be checked for accuracy to rule out a faulty unit.

The current number and variety of data loggers available is huge and ever-expanding. It is vital to identify the criteria with which to make a choice of equipment for each specific application. With new developments taking place so quickly, we can look forward to a time of even greater choice and improved specification. ◆

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