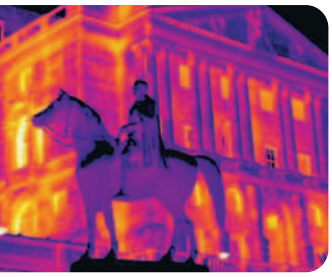
# The heat

There is a world of difference between art, black art and science, but thermal cameras are ready to move from the former to the latter. Brian Tinham explains



Staggering though it may seem, infrared imaging is one hundred years old this year. It was in October 1910 that American scientist Professor Robert Williams Wood presented his lecture at the Royal Photographic Society (RPS) in London on 'photography by invisible rays'. That was followed by publication of his paper in the Photographic Journal and Wood went on to be the first to produce photographs using infrared radiation – an achievement that finally brought him international recognition in Time magazine in 1938.

So important has thermography now become that, in October this year, the RPS will be staging an exhibition on infrared imaging at its Bath headquarters. Indeed, this august body is also publishing features on the topic in its Portfolio Two magazine, with thermal images taken using Flir infrared cameras. As Andy Finney, convenor of the Infrared 100 working group, puts it: "Infrared lets us see the world in a different way and even lets us see the birth of stars. How exciting is that?"

With such a proud and long heritage, surely thermal imaging technology should be near the peak of sophistication by now? Surely also thermal cameras, and even basic infrared point-and-click pyrometers, should be bread and butter for self-respecting maintenance engineers concerned with the safe and efficient operation of both electrical/electronic and mechanical equipment?

Well, yes and no. The truth is there is a world of difference between art, black art and science. So, yes, the underlying technologies are well established. And yes, sophisticated, yet robust and 'easy to use' hand-held instruments have become almost commodity items, with prices falling (although not quite through the floor), thanks largely to specialists, such as Flir, and their volume manufacturing. But no, although such devices are undoubtedly growing in popularity (and for good reason), they are not yet anything like standard pieces of kit in technicians' toolboxes. And no, they are probably not ready for that just yet – because there's still more to using them than meets the eye.

### Black art

So what is – or, for that matter, what should be – holding us back? Peter Clarke, managing director of thermal cameras supplier Radir, says it's all about training and understanding which tool to use for which job. He also believes that, in a sense, these devices have become victims of their own success – arguing that many are too powerful and too apparently easy to use. His point: engineers, technicians and plant managers alike are sometimes seriously misled by what they 'see' and so the image of thermal camera technology as a black art is wrongly reinforced.

That's why, on the one hand, some equipment languishes on shelves, barely used (having been bought and found misleading by the unwary), while, on the other, training providers and thermal imaging service organisations are making good money out of them. The fact is that, in the wrong hands, infrared cameras (just as with any tool) can give incorrect

## Hot tips on avoiding pitfalls

Understanding the environment in which you're using an infrared camera is vital to getting accurate results. Flir training manager Jon Willis says that means first setting the device for 'T reflected' (reflected apparent temperature) and the material emissivity (radiation potential, which relates to how shiny or dull the surface is).

"T reflected tells the camera how much of the radiation it sees in the environment is reflected," explains Willis. "ISO 18434-1: 2008 defines two methods –reflective and direct. We prefer the reflective method, which entails using a diffuse reflector – say crumpled foil – to measure the average temperature the camera is seeing. With the direct method, you stand with your back to the target and try to eliminate reflections in the immediate environment."

Similarly, there are two accepted procedures for establishing your target's emissivity. Flir's preferred method is to use the camera, following the procedure set out in ISO 18434. The alternative is to use look-up tables. "You don't have to do this every time. The more experience you gain, the more you know how a material is going to react," advises Willis.

But there are other basics, such as which buttons to press to get the best out of the camera, ensuring that the image is in focus and even image composition. "An unfocused image is not going to give correct temperature, but you also need to fill the viewfinder with your target to get the best results," says Willis. And then, where buildings are concerned, he also alludes to the need to understand wind speed, humidity and other factors likely to influence not only temperature readings, but also their significance.

Apart from these points, Radir managing director Peter Clarke emphasises the importance of facilities such as voice annotation and 'picture in picture' hybrids that superimpose standard and thermal images, to aid recognition and accuracy long after a visit has been forgotten.

"Being able to upload and look at the picture you took last month, and see the angle you took it from and where you were standing, can be invaluable, if you're looking for trends. Then listening to the voice annotation and remembering plant loading completes the picture."

# is on

results. Equally, in experienced hands, they are extremely effective at finding problematic faults – importantly, including those that are expected.

"The problem is that the colours mean nothing at all, until you know what to look for," explains Clarke. That's partly to do with how a camera is set up; partly also the nature of the material being examined and its environment; and partly the operator's knowledge of likely and/or acceptable temperatures for different plant and equipment. "For example, if you look at a three-phase installation and find a colour difference on one cable, that might be caused by an under-spec diameter on one phase or a phase imbalance," says Clarke. And there are other potential reasons.

## Plant loading

Then again, he points to issues on conveyors: "Technicians need to understand the impact of aspects, such as ambient conditions and loading on moving plant. In winter, all plant may look blue on the screen, while in summer it's red, but that doesn't mean there's an issue. If conveyors are running under a low load, but a bearing looks hot, that's a real problem."

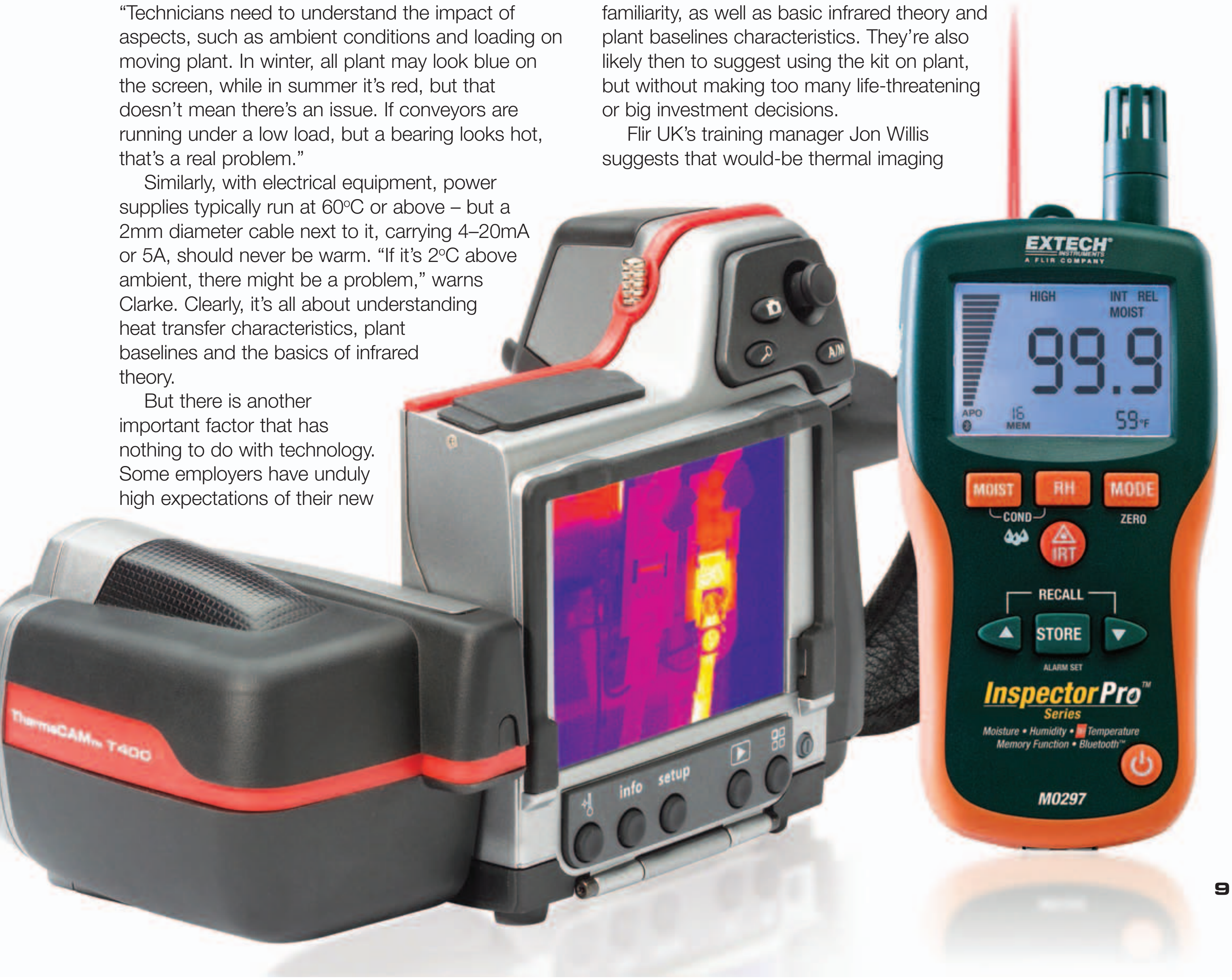
Similarly, with electrical equipment, power supplies typically run at 60°C or above – but a 2mm diameter cable next to it, carrying 4–20mA or 5A, should never be warm. "If it's 2°C above ambient, there might be a problem," warns Clarke. Clearly, it's all about understanding heat transfer characteristics, plant baselines and the basics of infrared theory.

But there is another important factor that has nothing to do with technology. Some employers have unduly high expectations of their new equipment and its novice users. Radir, which is accredited by infrared certification firm Snell, reckons that, after its start-up course, it encourages trainees to use equipment around the home before taking it on plant to make maintenance decisions. But then, as Clarke puts it: "Their employers may say, 'I've spent the money on the kit and the training, so get out there and use it'." And, again, the danger is that expensive mistakes are made, plant that didn't need to be pulled is rebuilt or replaced and the camera falls into disrepute.

So what should you look for in training? Best advice is to start with the basics before moving on to more advanced training – but not to cut corners on the latter. If you find a vendor suggesting that one day of training is enough, you might want to look elsewhere. Most reputable firms will advise starting with a full day that covers instrument familiarity, as well as basic infrared theory and plant baselines characteristics. They're also likely then to suggest using the kit on plant, but without making too many life-threatening or big investment decisions.

Flir UK's training manager Jon Willis suggests that would-be thermal imaging

**Infrared cameras have advanced beyond recognition, but beware the salesperson who tells you they're easy to use. They are, but getting accurate readings is another issue**



technicians consider getting their training through any body certified by BINDT (the British Institute of Non-Destructive Testing) to the ISO 18436-8 thermography condition monitoring competence standard. He accepts that these are not free (costs are typically £225 for a single day and £1,465 for five days), but insists that there are "so many parameters related to thermography" that they will need guidance. And that must cover everything from how to set the camera up, in terms of emissivity and T reflected (see panel) for the plant environment concerned, to how to analyse thermal patterns found, and how to deliver valid reports.

Radir's Clarke agrees, and adds that his helpdesk is also always ready to take calls and even emails of images that are causing concern. "Users might be concerned about a hot spot they think they've found, but we might advise that it's just a reflection of the furnace behind them," he explains.

### Engineering competence

Both say that best advice for serious users is go on a five-day Level One course, or similar, that takes engineers and technicians to the next level of proficiency. That should cover the requirements of the vast majority. However, for professional surveyors or engineers wanting to use the equipment to back up substantial plant investment and/or change decisions, Level Two is the best policy. "If users want to become really proficient, then they need to attend a five-day, 40 hour training course. Only then will they be able to operate the camera, accurately interpret thermal images and put together accurate reports," advises Willis.

One point, though: if you are setting up a thermal inspection programme and you believe you know where your problems are likely to be, you may not even need a thermal camera. As Clarke puts it: "A point-and-read pyrometer, costing a few hundred quid, may be good enough. And there's no loss in accuracy. However, the difference with a camera is that it finds the hot spots for you – including those you didn't anticipate, such as a 2mm cable, near the 100A terminations you were due to inspect, that's even hotter."

So, if it's all about inspections of plant at specific locations, then an infrared gun is enough. But then don't expect to find hot spots that weren't on your schedule; don't expect to be able to plan that panel rebuild you didn't see trending up in temperature; and don't expect to prevent that fire you didn't see coming.

Just one final thought: be aware of the power of fixed infrared sensors to solve difficult plant temperature problems. Corus' Swinden Technology Centre, in Rotherham, is using some to monitor the temperature of steel strip on its experimental rolling mill, which is aimed at verifying best cooling methods for different steel strip products, and various types and grades of steel. The rolling mill, which is one-eighth size, will incorporate four infrared temperature sensors, measuring process temperatures at various positions along the line.

Garry Beard, development engineer at the centre, explains that two Micro-Epsilon ThermoMeter CTM2 sensors are already in position on the high temperature rolling side. The other two will be located on the cooling conveyor, one at the start and another low temperature version at the end of the cooling system. Temperatures on the rolling side vary from 850°C to 1,100°C, while, on the cooling side, they are down at 600°C.

"The size, accuracy and repeatability of the sensors swayed our decision. Micro-Epsilon was also happy to lend us a trial sensor to enable our engineers to try it out. We also had an onsite demonstration of the sensor and excellent technical support," comments Beard. PE

## Pointers

- Infrared cameras are passive devices that see any radiated heat
- Image spot size has to be valid for true temperature
- Knowing the emissivity of your target is crucial to temperature accuracy
- For naked metals, you may need stickers or polymer coatings
- Thermal imagers cannot see through polycarbonate or thermal shields
- Always note loading conditions when taking baseline measurements
- Always try to take measurements under high load (electrical current or bearing force) conditions
- Above all, work safely and don't jump to conclusions

## Emissivity, T reflected and wavelength

Emissivity and wavelength are key factors determining accuracy. To understand the former, you need to know that all materials radiate infrared energy in three ways: emitted, reflected from their surroundings and transmitted through themselves (negligible for solids). Shiny metals have low emissivity, because they are poor emitters, but radiation reflected by their surroundings is likely to be proportionately high.

Instrument manufacturer Micro Epsilon gives the example of freshly milled steel at 20°C, which has an emissivity of 0.2, set against reflected energy of 0.8 – meaning that 80% of the emitted heat energy from the object is reflected from surrounding objects. However, at 1,100°C, the same material has a typical emissivity of 0.6.

Then there is the wavelength, which is only a problem for infrared sensors. Since emissivity varies according to the measurement wavelength, infrared sensor manufacturers design sensors that maximise emissions for different materials. For metals, the preferred range is 0.8 to 2.3μm, glass 5μm, textiles and most matt surfaces 8–14μm. Plastics are in a different league, requiring specific wavelength sensors: for example, polyethylene, polypropylene, nylon and polystyrene use 3.43μm, while polyester, polyurethane, Teflon and FEP require 7.9μm.

Micro Epsilon is offering a free guide: The Basics of Non-Contact Temperature Measurement. Go to: www.micro-epsilon.co.uk. Fluke is giving away a 72-page 'Introduction to Thermography Principles'. Go to: www.fluke.co.uk/ti. Flir is providing free thermal image evaluation software online. Go to: www.flir.com/thg. And Raider is offering a free CD, covering infrared theory and application notes.