Alternative detection

Phil Cunliffe explains how the development of smoke detection technology, which combines optical and heat sensing in one detector, offers an effective non-radioactive alternative to ionisation smoke detectors

IN THE early 1990s, Tyco introduced a new concept in fire detection combining an optical smoke sensor with heat sensors. This new type of detector has now been in use for more than 20 years, during which time it has provided reliable fire detection of smoke generating fires, as well as better immunity to false alarm sources compared with the previously used single technology detectors.

For the decades prior to the advent of optical smoke detectors in the 1970s, ion chamber smoke detectors (ICSDs) had a virtual monopoly in smoke detection applications. Because of this, it can be said that ICSDs have been the principal contributor to the development of automatic fire detection and alarm systems, the associated increase in the safety of occupants of buildings in case of fire and the decrease in property losses recorded during this period. However, some aspects of the performance of ICSDs have led to their decline, to the extent that a number of global UK and European manufacturers have ceased to offer them to system designers and installers.

Although the ability has long been recognised of ICSDs to quickly detect fast burning fires and fires that produce the lighter smoke particles, there has been an increased awareness that ICSDs do not perform well in detecting smouldering fires and/or fires that produce heavy and dark smoke particles – a major risk in fires involving modern furniture.

ICSDs have also proved susceptible to a wide range of false alarm sources, possibly with the exception of steam from a shower or kettle. The very straightforward design of ICSDs that has made them a workhorse of the fire detection technologist has also been a contributing factor in adapting them to resist this false alarm risk.

Finally, the mounting burden of national and international regulations regarding radioactive sources has made it increasingly costly for companies to manufacture ICSDs and ship them to installation sites.

Influence of standards

The performance of smoke detectors, ie their sensitivity to a range of fire scenarios, is greatly influenced by European (EN 54-7), International (ISO 7240-7) or US (UL 268) standards, which specify how they respond to a given smoke concentration. These standards are specified by various national codes and, because of this, they have become compulsory for complying with legal as well as 'ethical' obligations on risk assessors, system designers and installers. It is interesting to note that these standards generally do not differentiate between ICSDs and optical chamber type smoke detectors (OCSDs) when determining their response to fires. It is assumed that both are suitable for general use and both should respond to a wide range of smoke types. EN 54-7, ISO 7240-7 and UL 268 do not insist that all detectors should have the same sensitivity to all smoke types, but establish criteria of smoke density versus response time that have to be met for a series of test fires.

Taking the example of EN 54-7 (also ISO 7240-7), a smoke detector would be required to respond to four test fires: TF2 (smouldering pyrolysis fire (wood)), TF3 (glowing smouldering fire [cotton]), TF4 (open plastics fire [polyurethane]) and TF5 (liquid fire [n-heptane]). For a detector to comply with EN 54-7, its sensitivity must be high enough to give an acceptable response to the least favourable fire type. Thus the sensitivity of smoke detectors is determined by their response to the test fires to which they are least sensitive. For ICSDs, this will be the slow smouldering fires and for optical detectors, the polyurethane and heptanes fires. Because of this, the sensitivity levels needed to meet the requirements of EN 54-7 are unrealistically high and lead to an increased risk of false alarms.

A critical view

This argument is particularly true of ICSDs, which are highly responsive to the invisible particles produced by many normal events. Events that produce large numbers of invisible aerosols favoured by ICSDs are usually accompanied by sufficient heat to transport the smoke particles to the detector, thereby guaranteeing a quick response. Unfortunately, this is also true for a range of naturally occurring non-fire events, which can lead to false alarms.

On the other hand, there is a wealth of evidence of the failure of ICSDs to respond to very dense smoke generated by overheating electrical equipment or smouldering soft furniture such as bedding. There is no such evidence regarding the performance of OCSDs, which have become the detector of choice for this type of fire risk.

The deficiencies of ICSDs are further compounded by the adverse effect on their sensitivity to smoke of air movements and variation in atmospheric pressure.

OCSD effectiveness

A new class of optical detector introduced by Tyco in the 1990s has largely overcome the poor response to clear flaming fires. The introduction of the new high performance optical detector (HPO) has been a key contributor in providing safer detection of a wide range of smoke, while reducing false alarm risks previously associated with ICSDs. As a relatively recent technology, optical detectors have come with a number of shortcomings of their own. One of the major problems encountered with OCSDs in the early days was their sensitivity to insect infestation, especially the tiny thrips or corn flies that appear at harvest time. These small insects have caused an immense number of false alarms, particularly in rural areas each summer. The sensitivity of OCSDs to white dust has also resulted in high false alarms in some applications. Both of these limitations have been overcome by new, ingenious optical chamber designs and improved signal processing. For example, the patented design of the Tyco smoke chamber significantly reduces the effect of dust and entirely eliminates the false alarms caused by thrips, as proved by the accumulated experience of 15 million detectors and summers with no reported false alarms due to thrips.

HPO detectors

One characteristic of flaming fires is that they produce large amounts of heat, giving a significant rise in temperature. HPO detectors were one of the first

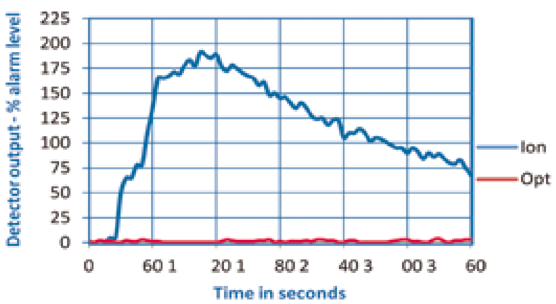

Figure 1. Response of ion-chamber and optical detectors to a dusty gas heater

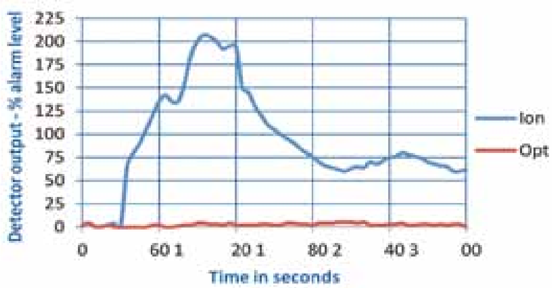

Figure 2. Response of ion-chamber and optical detectors to soldering a plumbing joint

Figures 1 and 2 are good examples of naturally occurring events, which can easily cause false alarms. Figure 1 shows the response to the lighting of a portable gas heater which had become dusty after a period of non use. Figure 2 shows the response to a plumber heating a soldered pipe fitting. In each case, the ICSD can be seen to respond quickly, whereas the OCSD can be seen to produce only a very small signal.

smoke detectors to exploit the possibility of using this temperature rise in combination with the small amount of optical scatter produced during flaming fires.

The design of the HPO detector is based on the false alarm resistance of the optical detector design. It was formulated after analysing data collected from a large number of fire tests consisting of EN 54-7 test fires, additional test fires such as EN 54 TF1 and decalin as well as a number of more realistic experimental fires. The rise in temperature in the early stages of a flaming fire was seen to be much higher than that occurring in 'normal' conditions. The level of visible smoke, although below the normal optical detector alarm level, was higher than that present in normal conditions. It was concluded that this rapid rise of temperature could be sensed and used to adjust the sensitivity of an optical detector sensor dynamically to give a considerable improvement in the response to flaming fires without increasing the probability of false alarms.

The optical array assembly and smoke entry labyrinth are similar to those used in Tyco's current range of optical detectors, which have successfully eliminated the false alarms caused by thrips and greatly reduced the effect of light-coloured dust on detector sensitivity. To sense the temperature rise, a thermistor has been added to the electronic assembly. The thermistor provides information to the detection algorithm software on the dynamic changes in temperature that may occur during a fire. Hence, the sensitivity of the smoke sensor increases proportionally with dynamic increases in temperature until the pre-determined alarm response threshold is reached.

It is important to realise that the HPO is not a heat detector and will not respond to temperature alone. Whatever the degree of enhancement achieved, the HPO remains a smoke detector. It is also worth noting that the HPO is so designed as to ignore drops in temperature.

Fire behaviour

The nature and development of fires in buildings are mostly unpredictable, as many different combustible fuels, (eg soft/hard, natural/synthetic materials) may be involved and the environment where the fire develops may vary due to circumstances present at the time, (eg temperature, ventilation/air circulation, open/closed doors/windows). The way the fire itself starts can also be an influential factor, (eg a non-extinguished cigarette end, an electrical fault or even an arson attack).

Because of this unpredictability, the reliable detection of fires in buildings can be greatly improved with detectors that are able to give a more uniform response to the range of fires and environments which can occur. That is, detectors that are able to analyse not just the kind of smoke present, but also other environmental parameters that occur during a fire condition, such as changes in temperature.

The HPO offers equally good response to fast developing, clear burning, flaming fires, as it does to the slow developing, smouldering fires. This was illustrated effectively by the response characteristic of the HPO to the series of test fires specified in the EN 54 (and ISO 7240) series and comparing it to that of ICSDs and OCSDs. The response thresholds were tested in terms of smoke obscuration mA (dB/m) for the three types of smoke detectors, ICSD, OCSD and HPO. These responses were taken as the mean value obtained from four detectors to average out the variations that can occur between test fires.

The alarm threshold responses clearly showed that the HPO detector gives the most consistent response across all four test fires compared with the other two types of smoke detectors. They also demonstrated that the HPO detector, by using the rise in temperature, produces a response equivalent to, or better than, that of the ICSDs in the flaming test fires TF4 and TF5.

It is important to recognise that, in spite of offering performances to compete with ICSDs in flaming fires in potential false alarm situations such as those shown in Figures 1 and 2, the HPO behaves like a normal optical detector. Experience has shown that this significantly reduces the incidence of false alarms.

The way ahead

ICSDs have been the mainstay of the fire detection industry for several decades and have undoubtedly saved many lives and significant asset losses. While their detection performance for flaming fires is not in question, there is a growing awareness of the problems associated with the use of radioactive sources and of the potential for false alarm from 'normal' events.

The availability of low cost, reliable optical detectors (OCSDs), has done much to shift the emphasis away from ICSDs, but the performance of optical detectors in flaming fires has always limited their acceptance by the industry.

The introduction of the HPO has extended the fire detection range of OCSDs to provide good performance in both flaming and smouldering fires, making them a perfect solution for fire risks from modern materials in dwellings, as well as in commercial and industrial premises. This new type of smoke detector offers the user the possibility of reduced false alarms without any real sacrifice in detection capabilities ■

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