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White Paper
How multi-sensor fire detectors can help
to reduce false alarms

Foreword

In modern fire detection technology, multi-sensor fire detectors play a decisive role in the early detection and prevention of fires. These innovative devices combine various sensor technologies to ensure precise and reliable detection of fire events.

This document is intended for fire safety professionals, building managers, and regulatory authorities. It aims to provide general information on the use of multi-sensor fire detectors to reduce unwanted alarms. While great care has been taken in the compilation and preparation of this publication to ensure accuracy, Euralarm cannot accept responsibility for any errors, omissions, or advice given, nor for any losses arising from reliance upon the information contained herein. Please note that national and local requirements on maintenance may also need to be considered when using this document.

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Today's fire detection has a long history that traces back to ancient civilizations, where early humans relied on basic methods such as watchtowers and fire guards to spot and respond to fires. With the advent of industrialization in the 19th century, the need for more sophisticated fire detection systems became apparent, leading to the invention of the telegraph-based fire alarm systems in the 1850s. These early systems utilized telegraph lines to transmit fire alerts to central stations.

Over the years, fire detection technology evolved significantly, incorporating advances in electronics, sensors, and computer algorithms. By the mid-20th century, the development of smoke detectors, heat detectors, and flame detectors revolutionized fire safety. Today, modern fire detection systems leverage cutting-edge technologies, such as infrared and ultraviolet sensors, air quality monitoring, and machine learning, to provide rapid and accurate fire detection, thereby minimizing damage and saving lives.

Introduction

Fire detection is a critical component of building safety systems in residential, commercial, and industrial settings. It is aimed at early identification and alerting of fire incidents to minimize damage and save lives. Traditional fire detection systems, typically based on smoke, heat or flame detection, each have their strengths but also limitations. Smoke detectors can be triggered by non-fire-related particulates, heat detectors may respond too slowly, and flame detectors are often limited to line-of-sight applications. These traditional detectors use independent signal processing: they analyze each signal or each feature of the signal independently, without integrating the information from various sources or criteria. This means that each signal characteristic (e.g., amplitude, frequency) is processed independently.

Multi-sensor fire detectors address the limitations of single-criteria detectors by combining multiple sensing modalities. This integrated approach improves detection accuracy, reduces false alarms, and achieve a faster response to actual fire events. This white paper explores the development and use of multi-sensor fire detectors. These advanced sensors integrate multiple detection technologies to enhance reliability, accuracy, and response times, thereby improving overall fire safety.

Main technologies

Multi-sensor fire detectors typically measure different physical or chemical properties of fire products. Each additional "axes" can provide complementary information that helps to characterise the source. Most common and much used are combinations of these detection technologies:

Optical Smoke Detection

Optical smoke detectors usually use a light source and a photoelectric sensor to detect smoke particles. When smoke enters the detection chamber, it scatters the light, which is then detected by the sensor. Depending on the wavelength of the light emitting sensor, the detection of particles of different sizes is an effective method to detect fires.

Heat Detection

Heat detectors monitor ambient temperature and the rate of temperature increase. According to EN 54-5 each point-type heat detector reacts to both of them. By using detectors with the category index R or S it is possible to focus one of these two methods.

Gas Detection

Gas detectors identify the presence of specific gases such as carbon monoxide (CO) or hydrogen cyanide (HCN), which are often by-products of combustion. CO detection is particularly valuable in early fire detection, as CO is typically produced in the initial stages of a fire.

Specialty technologies

The aforementioned technologies can also be combined with other detection technologies to create solutions for special applications. Among these technologies are:

Flame Detection (non-imaging) uses ultraviolet (UV) or infrared (IR) sensors to detect the presence of flames. UV sensors respond to the UV radiation emitted by flames, while IR sensors detect the heat radiation. Some systems use a combination of both UV and IR to improve accuracy and reduce false alarms from non-flame sources.

Air Quality Monitoring measures various parameters such as particulate matter, volatile organic compounds (VOCs), and overall air quality index. Changes in air quality can indicate early stages of combustion or the presence of fire-related pollutants.

Temperature Gradient Sensing monitors temperature differences across different points. A sudden temperature gradient can indicate the presence of a fire, as opposed to uniform heating from other sources. This method helps in detecting fires that develop rapidly.

Acoustic Sensing detects the sound of fire-related phenomena such as the crackling of flames or the breaking of glass. Although this technology did not yet find its way to the multisensor detector so far, it can provide supplementary data to confirm a fire event when used alongside other detection methods.

Particle Analysis uses advanced particle analysis techniques, such as laser-based particle counters, to differentiate between different types of airborne particles (e.g. dust, smoke, steam). This helps in reducing false alarms by distinguishing fire-related particles from benign ones.

Machine Learning and AI Algorithms enhances the processing and analysis of data from multiple sensors. These algorithms can identify patterns and correlations between different types of sensor data, leading to more accurate and timely fire detection. This technology may be used to develop algorithms with more complex ways of combining sensor data. Once approved, it would be likely that the algorithm is fixed.

Networked Sensor Arrays uses a network of interconnected sensors that can improve coverage and accuracy. Data from multiple sensors can be aggregated and analysed to provide a more comprehensive picture of the environment, enabling better detection of fire incidents.

Environmental Monitoring uses sensors for humidity, pressure, and other environmental factors that can affect fire behaviour and detection accuracy. Monitoring these parameters helps in fine-tuning the detection algorithms for various environmental conditions.

Relevance of multi-sensor fire detectors

Multi-sensor fire detectors combine multiple types of sensing technologies with the goal to identify fires more accurately and quickly than traditional single-criteria detectors. Below the relevance of the detectors is highlighted.

Enhanced detection accuracy

Multi-sensor fire detectors integrate different sensing modalities, such as smoke, heat, and gas sensors. This combination allows the detector to cross-verify signals, significantly reducing the chances of false alarms. For instance, a detector might use an optical sensor to detect smoke, an electrochemical sensor to detect Carbon monoxide, and a thermal sensor to measure temperature rise. By analysing data from all these sources, the detector can more reliably determine the presence of a fire.

Reduced false alarms

False alarms can be costly and disruptive. Multi-sensor fire detectors are designed to minimize these by using multiple criteria for triggering an alarm. For example, a sudden temperature increase might trigger a heat sensor, but if there's no corresponding increase in detected smoke particles, the alarm might not be triggered. This selective approach helps to avoid false alarms caused by non-fire-related activities, such as cooking or steam.

What are false fire alarms?

A false fire alarm is an event where a fire alarm system is triggered and activates without the presence of an actual fire or fire-related emergency. False alarms can have various origins and are essentially subdivided into three groups:

- "technical defects" which are triggered by defects of technical equipment or components (e.g., sensors, detectors, control panels, or cables).

- deceptive alarms. In such cases, there is no fire and the technical devices are functioning properly. However, the sensors react to parameters of fire-like phenomena (e.g. water vapor, dust, and solar radiation) in the absence of an actual fire.

- malicious alarms and alarms with good intent triggered by human activities. In the event of malicious alarms, for example, persons trigger manual call points or light matches underneath fire detectors with malicious intentions. In the event of false alarms with good intent, the persons alert the fire services in an act of (mistaken) good faith although, here as well, there is no fire. This third group of alarms is similar to deceptive alarms because, as before, the equipment functions as intended, but the alarms are not triggered by physical or chemical parameters as is the case with deceptive alarms. Instead, human behaviour plays a decisive role in this third group. The difference between malicious and good intent activities lies in the person's particular intention.

False fire alarms can have several negative consequences. They cause unnecessary evacuations and interruptions in business operations, education, or daily routines. Frequent false alarms can lead to indifference, where people might not respond appropriately to actual alarms. Fire services may be diverted to non-emergency situations, potentially delaying response to real emergencies. And last, but not least repeated false alarms can incur significant costs for businesses and institutions, including fines, and potential damage to reputation.

Initiatives to reduce false fire alarms involve proper installation and maintenance of fire alarm systems, educating users about the causes of false alarms, and implementing stricter regulations and penalties for intentional misuse. Selection of the most appropriate detector for the area is key to mitigating the risk of false alarms and multi-sensor detectors often provide suitable and effective response which make them particularly relevant to this objective.

Faster response time

By utilizing multiple detection methods, multi-sensor fire detectors can respond more quickly to real fire events. Different fires can produce different types of signals; for example, flaming fires produce more heat, while smouldering fires produce more smoke. Multi-sensor fire detectors can recognize these variations and activate alarms faster than single-sensor devices, which might miss certain types of fires or react slower.

Adaptability to various environments

Different environments pose different fire detection challenges. Multi-sensor fire detectors can be adjusted to suit specific settings, such as residential buildings, commercial spaces, industrial sites, or public institutions. Their ability to combine and interpret multiple signals makes them versatile and effective in diverse conditions, enhancing overall safety.

Compliance with stringent safety standards

Regulatory bodies and safety standards increasingly favour advanced fire detection technologies, which are already standardised, to enhance safety. Multi-sensor fire detectors often meet and exceed these stringent standards, providing a higher level of protection and ensuring compliance with local fire safety regulations.

Economic benefits

While multi-sensor fire detectors might have a higher initial cost compared to single-criteria detectors, they can offer significant economic benefits in the long run. Reduced false alarms mean fewer unnecessary evacuations and less disruption to business operations. Additionally, their faster and more accurate response can potentially minimize fire damage, reducing repair and recovery costs.

Technological integration

Multi-sensor fire detectors often come with advanced features like network connectivity, integration with building management systems and remote monitoring capabilities. This allows for centralized control and monitoring, easy maintenance and better data analysis for improved safety management.

In summary, multi-sensor fire detectors offer significant advantages over traditional fire detection methods. Their ability to combine and analyse multiple types of data not only enhances the accuracy and speed of fire detection but also reduces false alarms, adapts to various environments and provides economic benefits through reduced disruptions and damage.

Multiple modes

Although this feature is not limited to multi-sensor fire detectors many of them offer the option for setting different modes to enable their performance to be configured to suite a variety of environments and conditions.

By offering different modes, multi-sensor fire detectors can be fine-tuned to provide optimal performance in diverse environments, ensuring both safety and convenience.

Some common modes and features available in multi-sensor fire detectors are:

- Day/Night Mode.
  During the day, when the building is occupied and there might be more activities that could trigger false alarms (like cooking or cleaning), the detector can be set to a mode that is less sensitive. At night, when the building is less occupied, the detector can be set to a more sensitive mode or the detection of an additional fire phenomenon to ensure quick detection of any fire hazards.

- Enhanced Sensitivity Modes.
  The High Sensitivity Mode increases the sensitivity of the detector, making it more responsive to smaller amounts of smoke or heat. It is useful in high-risk areas where early detection is critical. The Low Sensitivity Mode reduces the sensitivity to prevent false alarms in areas where non-threatening smoke or heat might be present frequently.

- Environmental Adaptation Modes.
  Depending on the environment where multi-sensor fire detectors are used the standard operating (or normal) mode is set for general environments where normal sensitivity is appropriate. The Harsh Environment Mode adjusts sensitivity and alarm thresholds to account for challenging conditions such as high dust, humidity, or airflow, which could otherwise trigger false alarms.

- Maintenance and Test Modes.
  The Test Mode, that is also available on newer detector ranges, allows the multi-sensor fire detector to be tested without triggering the building's fire alarm system. This is useful during routine maintenance checks. The Maintenance Mode temporarily adjusts or disables certain functions to facilitate maintenance activities without causing false alarms.

- Alarm Verification Mode.
  This mode implements a delay or verification period where the detector seeks confirmation of a fire condition from multiple sensors before triggering an alarm. This helps reduce false alarms.

Some detectors allow for the creation of custom profiles where sensitivity and response settings can be tailored to specific requirements of different zones or rooms within a building. A manual override provides authorized personnel the option to manually adjust settings or modes in response to specific, temporary conditions or during emergency drills.

Important standards

The EN 54 series of standards pertains to fire detection and fire alarm systems, ensuring their reliability, functionality, and compatibility. The specific standards each cover different types of detectors, but together they contribute to a comprehensive fire detection system. Here is how they work together:

- EN 54-5: Heat Detectors
  EN 54-5 specifies the requirements for point heat detectors intended for use in fire detection and fire alarm systems installed in and around buildings. These detectors are designed to respond when the convected thermal energy of a fire increases the temperature of a heat sensitive element.

- EN 54-7: Smoke Detectors
  EN 54-7 specifies the requirements for point smoke detectors that operate using scattered light, transmitted light, or ionization. These detectors are designed to detect visible and invisible smoke particles, providing early warning of fire. They are essential for detecting fires at an early stage when there is still time to evacuate occupants and control the fire.

- EN 54-26
  EN 54-26 specifies the requirements for point detectors using carbon monoxide sensing. These detectors can react promptly to smouldering fires involving carbonaceous materials because CO does not depend solely on convection, but also moves by diffusion. CO fire detectors might be better suited to applications where other fire detection techniques are prone to false alarms, i.e. due to dust, steam, and cooking vapours.

Next to single sensor point detector standards there are the multi-sensor point detector standards EN 54-29, EN 54-30, and EN 54-31. These multi-sensor point detectors improve the accuracy of fire detection by assessing multiple criteria, thereby reducing false alarms.

The multi-sensor standards in detail:

- EN 54-29: Multi-sensor detectors using a combination of smoke and heat sensors
  EN 54-29 deals with point detectors that combine smoke and heat sensors. These multi-sensor detectors improve the accuracy of fire detection by assessing multiple criteria, thereby reducing false alarms. Although these detectors may be allowed to react to only one fire phenomenon, they are particularly useful in environments where smoke or heat alone may not provide a reliable indication of fire, such as in areas with elevated levels of dust or steam.

- EN 54-30: Multi-sensor detectors using a combination of CO and heat sensors
  EN 54-30 deals with point detectors that combine CO and heat sensors. They are particularly useful in environments where CO alone may not provide a reliable indication of fire, such as in areas with free-burning, open, well-ventilated fires.

- EN 54-31: Multi-sensor detectors using a combination of smoke, CO and optionally heat

  EN 54-31 deals with point detectors that combine smoke, CO and heat sensors. They are particularly useful in environments where single sensors alone may not provide a reliable indication of fire, cover a broad range of possible fire situations and may be very robust against non-fire situations.

Compliance with EN 54 standards ensures that fire detection systems meet the required performance and safety criteria set by European regulations. This compliance is crucial for the certification and approval of fire alarm systems in distinct types of buildings. However, only the single sensor point detector standards EN 54-5 and EN 54-7 are covered by European Construction Product Regulation (CPR) and not any multi-sensor detector standards. That means that each multi-sensor point detector must also fulfil one of the standards EN 54-5 or EN 54-7 to be recognized as construction product under the CPR. Using more robust multi-sensor fire detectors which are compliant also with EN 54-29, EN 54-30 or EN 54-31 is voluntary.

Roadmap for deploying multi-sensor detectors

Using multi-sensor fire detectors effectively involves a comprehensive approach that starts with a thorough needs assessment and continues through careful system design, installation, regular testing, maintenance, and training. By following this roadmap, you can ensure that your fire detection system is reliable, effective, and compliant with relevant standards and regulations[1].

The steps of the roadmap are:

1. Understanding the Environment

   When choosing detectors for fire detection systems consider whether the building is residential, commercial, industrial, or mixed-use, as different environments have different fire risks and detection requirements. Also factors such as temperature variations, humidity levels, airflows, and the presence of dust or fumes, should be evaluated. These factors can affect the detector performance considerably. Apart from the building itself it is also important to understand the building's occupancy patterns, the nature of activities conducted, and potential fire hazards associated with those activities. Also, consider if there are changes to be expected in the environment within the monitored rooms or areas.

2. Detector Capabilities and Features

   Based on the specific fire risks in the environment detectors should be chosen that combine appropriate sensors (e.g., smoke, heat, carbon monoxide). Ensure that the detectors have adjustable sensitivity settings to tailor detection to specific conditions and minimize false alarms. One option is to look for features that verify alarms through multiple criteria to reduce false positives.

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[1] For detailed guidance, you can refer to EN 54-29 and manufacturer documentation, which provide more specific instructions tailored to different types of detectors and environments.

3. Compliance with product Standards
   Ensure that the chosen detectors comply with local fire safety regulations and building codes and verify that the detectors meet recognized industry standards, such as (depending on location) EN 54 which certify their reliability and performance. Note that while EN 54-5 and EN 54-7 are harmonized under EU Regulation, the multi-sensor standards EN 54-29, EN 54-30 and EN 54-31 are not.

4. Integration with Existing Systems
   Ensure that the multi-sensor detectors are compatible with the existing fire alarm control panel and other components of the fire safety system. Check the communication protocols used by the detectors (e.g., analogue, digital, wireless) and ensure they integrate seamlessly with the overall system. Confirmation that the interaction of the fire detector together with the fire alarm control panel has been tested in accordance with EN 54-13 can provide security here.

5. Installation Considerations
   Plan the placement of detectors to ensure adequate coverage of all areas, taking into account the layout and potential obstructions. The spacing of detectors should adhere to the local installation codes - taking into account the mode of operation. Ensure detectors are accessible for regular maintenance, testing, and replacement.

6. Maintenance and Testing
   Plan for routine maintenance to keep detectors functioning correctly, including cleaning, testing, and calibration. Establish protocols for regular functional testing to ensure detectors respond correctly to fire conditions. Maintain detailed records of maintenance and testing activities to ensure compliance and facilitate troubleshooting. Handover the maintenance routines to a service-provider, who fulfils the requirements of EN 16763. Remember that fire detectors are open sensor systems, and that for safety reasons it is important to replace the fire detectors after a certain period of use.

7. Cost and Budget
   Consider the upfront costs of purchasing and installing multi-sensor detectors. Factor in long-term costs, including maintenance, testing, and potential replacements or upgrades. Conduct a cost-benefit analysis to weigh the enhanced detection capabilities and reduced false alarms against the overall investment.

8. Training and Education
   Ensure that building occupants and fire safety personnel are trained on the operation of the multi-sensor detectors. Incorporate the use of multi-sensor detectors into the building's emergency response and evacuation procedures.

9. Vendor Support and Service
   Choose detectors from reputable manufacturers with a track record of reliability and good customer support. Consider warranty terms and service agreements to ensure ongoing support

and assistance from the manufacturer.

By carefully considering these factors, you can choose multi-sensor detectors that are well-suited to your specific environment, provide reliable fire detection, and integrate seamlessly with your overall fire safety strategy.

Total cost of ownership

The comprehensive costs associated with deploying multi-sensor detectors in a fire safety system will vary based on factors such as the specific building requirements, local labor rates, and the chosen brands and models of detectors. The total cost of ownership (TCO) of multi-sensor detectors for fire safety applications includes various cost components throughout the life cycle of the detectors.

Examples are:

- Initial costs (purchase price, installation costs)
- Operational costs (power consumption, system integration)
- Maintenance costs (regular maintenance, calibration)
- Training costs
- Compliance and certification costs

The TCO of multi-sensor fire detectors includes both upfront and ongoing costs. While multi-sensor fire detectors may have higher initial costs compared to single-criteria detectors, their improved accuracy and reduced false alarms can result in long-term savings, particularly in environments where false alarms can be costly. It is essential to consider all these factors when budgeting for a fire detection system.

Relevant studies

Euralarm false alarm study

The Euralarm False Alarm Study provides a comprehensive analysis of the issue of false alarms, highlighting their prevalence, causes, and the significant impact they have on fire services and public safety. According to the study, false alarms constitute a substantial portion of fire alarm activations, often exceeding genuine fire events. These false alarms can result from a variety of sources, including system malfunctions, environmental factors (such as dust, steam, or cooking fumes), and human error. The study emphasizes that false alarms not only strain fire service resources but also pose a risk to public safety. Frequent false alarms can lead to complacency among building occupants and responders, potentially delaying reaction times in actual emergencies. Moreover, the repeated dispatch of fire services to false alarms incurs considerable costs and operational inefficiencies.

Euralarm's findings advocate for the adoption of advanced fire detection technologies, such as multi-sensor detectors, which can better distinguish between true fire conditions and benign sources of alarm. The study also recommends regular maintenance and testing of fire alarm systems, public education on proper usage, and the implementation of stricter regulatory

standards to reduce the incidence of false alarms. By addressing these factors, the Euralarm False Alarm Study aims to enhance the reliability of fire detection systems, ensuring that resources are appropriately allocated to genuine emergencies and improving overall fire safety.

Copies of the study can be downloaded [here](#).

BRE false alarm study

The Building Research Establishment (BRE) conducted a comprehensive study on false alarms in fire detection systems, revealing critical insights into the prevalence and causes of false alarms in various environments. The study found that false alarms account for a significant portion of fire service call-outs, leading to unnecessary disruptions, financial costs, and potential complacency towards genuine alarms. It identified that single-criteria detectors, such as traditional smoke or heat detectors, are more prone to false alarms due to factors like dust, steam, or minor temperature fluctuations. BRE's findings underscore the need for more sophisticated detection technologies, such as multi-sensor detectors, which integrate multiple detection methods to improve accuracy and reduce the incidence of false alarms. The study advocates for the adoption of these advanced sensors to enhance fire safety systems' reliability and effectiveness, ultimately ensuring a more robust response to actual fire events.

More information on this study is available [here](#).

False alarm investigation of Buckinghamshire & Milton Keynes Fire Authority

The Buckinghamshire & Milton Keynes Fire Authority has taken a proactive approach to investigate and mitigate false alarms, recognizing the significant impact they have on resources and public safety. False alarms, often triggered by non-fire-related incidents such as steam, cooking fumes, or system malfunctions, can divert essential fire and rescue services from genuine emergencies, potentially endangering lives. The Authority employs a systematic investigation process to identify the root causes of false alarms and implement targeted interventions. This includes educating the public and businesses on proper fire alarm system maintenance, improving alarm system technologies, and advocating for the use of multi-sensor detectors that can better discriminate between real fire events and false triggers. By analyzing patterns and sources of false alarms, the Buckinghamshire & Milton Keynes Fire Authority aims to reduce their frequency, thereby enhancing the efficiency and reliability of their fire response capabilities.

More information on this study is available [here](#).

Derbyshire Fire and Rescue Service (DFRS)

The Derbyshire Fire and Rescue Service (DFRS) has publicly addressed the issue of false alarms, underscoring their significant impact on emergency response resources and community safety. The DFRS reports that a considerable number of their call-outs are due to false alarms, often triggered by non-emergency situations such as cooking fumes, steam, dust, and faulty alarm

systems. These unnecessary call-outs not only waste valuable resources but also increase the risk to the public by potentially delaying the response to genuine emergencies.

DFRS has implemented several strategies to reduce the incidence of false alarms. These include working closely with businesses and property owners to ensure proper installation and maintenance of fire alarm systems, promoting the use of more sophisticated detection technologies like multi-sensor detectors, and conducting public awareness campaigns to educate about the common causes of false alarms and how to prevent them.

Additionally, DFRS advocates for regular reviews and risk assessments of alarm systems, suggesting that proper management and frequent testing can significantly decrease the likelihood of false activations. By addressing the root causes and educating stakeholders, DFRS aims to minimize the disruption caused by false alarms, thereby enhancing the effectiveness of their emergency response, and improving overall public safety.

Recommendations

Multi-sensor fire detectors offer significant advantages in enhancing fire safety through more accurate detection and reduced false alarms. Their strategic use in various environments, compliance with the mandatory EN 54-5 and EN 54-7 standards for point type fire detectors sold in the EU (voluntary for the non-harmonized EN 54-29, EN 54-30 and EN 54-31), regular maintenance, and consideration of total cost of ownership make them a valuable component of a comprehensive fire safety strategy.

Use multi-sensor fire detectors in offices and warehouses to cover large areas where distinct types of fire risks may be present.

By offering different modes, multi-sensor fire detectors can be fine-tuned to provide optimal performance in diverse environments, ensuring both safety and convenience. To ensure optimum use of the detector's features and possibilities it is important to understand the modes and what risks they match.

While the initial cost of multi-sensor fire detectors may be higher, their reliability and reduced false alarm rate can lead to cost savings over time by minimizing disruptions and maintenance costs. Reducing one instance of a false alarm could justify the additional investment costs – do not be tempted to cost engineer multi-sensor fire detectors out of a project.