Intelligent Fire Alarm Systems

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INTRODUCTION

The fire protection community faces growing needs for reliable fire-detection systems that give the earliest possible warning of fire. These needs draw attention to problems associated with false or unwanted fire alarms. Unwanted fire alarms can seriously undermine the effectiveness of installed alarm systems, interrupt business, and, at worst, may cause occupants to ignore the fire alarm system during an actual fire.

Historically, fire alarm manufacturers have addressed unwanted alarms through two approaches:

- Decreasing detector sensitivity. Maintenance personnel are able to set individual detectors to be less sensitive after the devices are installed to alleviate false alarms. Typically, detector sensitivity is only decreased; the sensitivity is rarely increased to improve detection capability.
- Using alarm verification. Alarm verification essentially introduces a detection delay time. When the detector reports an alarm condition, the fire alarm system waits for a specified programmed delay time (typically, a 30-second delay) to confirm that the detector continues to report an alarm condition. If the detector is in alarm after the delay time, the alarm sequence is actuated.

Although decreasing detector sensitivity and using alarm verification can reduce the potential for unwanted alarms, occupant notification may also be delayed

Intelligent fire alarm systems have been developed to address unwanted alarms while maintaining the desired level of detector sensitivity. Although the capabilities of intelligent systems vary between manufacturers, intelligent systems can provide a number of benefits, including faster occupant notification, increased detector sensitivity, and decreased potential for unwanted alarms. Also, intelligent systems can provide users with notification of needed detector maintenance.

INTELLIGENT VS. CONVENTIONAL DEVICES

Artificial intelligence has become a buzzword in many fields involving technical products. Intelligent systems have been used in virtually every technical field involving a wide range of industries, from systems designed for the space shuttle to many computer games. The term "artificial intelligence" is typically associated with systems that have the ability to reason or learn.

A number of new fire alarm products have become available, many of which are labeled as components of intelligent fire alarm systems. While intelligent fire alarm systems are not as advanced and sophisticated as what is typically thought of as artificial intelligence, they do incorporate some of the simple logic techniques incorporated in such systems.

Intelligent fire alarm systems were initially another name for addressable systems. Addressable systems provide a unique address for each detection device, providing a increased level of information to the user. Today's intelligent systems do more.

Currently, intelligent fire alarm systems incorporate detectors that use decision-making algorithms to determine alarm conditions. Some employ multisensor approaches, while others use multidetector approaches or profile comparisons. In most cases, measurements, such as smoke concentration and temperature, are received by one or more sensors. This information is then analyzed by specific algorithms to determine if these measurements indicate that a fire condition may be present.

Some intelligent detection devices make all the alarm decisions, while others report conditions to the alarm system control equipment which makes the alarm decision. Conversely, conventional fire alarm detectors use set thresholds in a single sensor to determine alarm conditions. Thus, conventional devices are rigidly designed to signal alarm conditions only after a specific level has been reached.

INTELLIGENT DEVICES

Fire alarm devices labeled as intelligent are usually thought of as analog-type detectors.[1] Analog-type detectors provide continuous, real-time measurements of air properties within a detection chamber which is, in turn, affected by the surrounding air. These detectors can have set thresholds such as conventional detectors to initiate an alarm sequence based upon these measurements. In addition, many intelligent detectors use algorithms to process levels lower than those threshold values set to indicate an alarm. These are defined here as prealarm signals. Prealarm signals can be compared with a number of analog signals from other detectors and sensors within the space, compared with previous signals received from the affected detector or compared with predetermined fire profiles obtained through fire tests. These techniques allow an increase in detector sensitivity, while decreasing the potential for false alarm potential.

To be listed or approved, intelligent detectors must meet the criteria for conventional detectors. As such, when an intelligent detector reaches the alarm threshold specified for conventional detectors, it must initiate an alarm signal.

A discussion of some of the decision-making algorithms used in intelligent fire alarm systems follows.

AUTOMATIC SENSITIVITY COMPENSATION

Dust, dirt, humidity, age, and other environmental factors affect smoke detector sensitivity. These factors shift the base reading of detectors closer to or further from an alarm threshold, depending upon the type of contamination and type of sensor. As this base reading is shifted, higher or lower concentrations of smoke are required for conventional detectors to reach the preset alarm threshold. This makes smoke detectors more susceptible to unwanted alarms or delayed activation over time.

Many analog detectors are designed with automatic sensitivity compensation. While detectors incorporating automatic sensitivity compensation, or "drift" compensation, may or may not be classified as intelligent detectors per the definition suggested within NEMA Training Manual on Fire Alarm Systems,[1] "drift" compensation is included within some intelligent detection and is discussed here to provide background.

Since the detectors have a continuous range of sensitivities, the alarm threshold can be shifted higher or lower, based on the analog prealarm signal. If the sensitivity increases as the detector becomes dirty, the alarm threshold is shifted upward within the detector's range of sensitivity, compensating for the increased analog readings. When, over time, the analog signal is shifted close to the upper sensitivity limit, the detector provides a maintenance signal, notifying the user of service requirements before unwanted alarms occur. This allows the detector to compensate for contamination and environmental factors while allowing for optimum detector sensitivity.

PRESET SENSITIVITY ADJUSTMENT

Detectors with preset sensitivity adjustments operate similar to those with automatic sensitivity compensation. This design adjusts the sensitivity according to preset conditions. Some spaces may routinely require an increase or decrease in detector sensitivity. For instance, a highly protected space may require a higher level of protection during off-hours or a night club may require a decrease in detector sensitivity during normal business hours to compensate for occupant smoking. This allows optimum sensitivities to be

used for each predictably changing background condition within a given space.

PROFILE COMPARISON

Fires tend to have unique smoke and heat profiles based upon specific fuels burning. For instance, fires in plastic materials tend to produce more smoke than fires in flammable liquids. Some fire alarm manufacturers have developed proprietary databases with details characterizing products of combustion for a large range of fuels. These databases include measurements of time-dependent properties, such as photoelectric detector readings, ionization detector readings, and temperature readings. Data have been grouped according to fuel packages and specific traits have been determined for each type of fuel package.

Although individual fire alarm manufacturers use different methods, analog measurements from individual detectors are compared with predetermined values obtained in fire tests. This allows detectors to filter out conditions that are not typically associated with fires. The comparison algorithm is based on the predetermined values obtained from testing. Therefore, large spikes in properties such as obscuration noticed when insects enter smoke chambers or large spikes in ionization values due to radio frequency interference can be recognized and ignored.

Since alarm verification allows detectors to use a time delay to confirm alarm conditions, the detector can use the alarm verification delay time to analyze the prealarm signal. If the prealarm value is consistent with conditions typically associated with fire conditions, the alarm is verified, and an alarm is reported immediately. Since unwanted alarm conditions are filtered out, detector sensitivities can be significantly lowered, allowing early detection of fires.

Various manufacturers use different methods with this approach. Some group the test results from various environments such as offices, warehouses, or hospitals, while others use a single-representative approach to compare recorded readings to actual readings.

MULTISENSOR COMPARISON

Detectors using multisensor comparisons operate similar to single-sensor comparison detectors described earlier. However, several methods of detection are used. Combinations of ionization, photoelectric, and heat detectors are incorporated into a single detection device. This device can then compare information from several different sources. This approach may enhance the ability to filter out unwanted conditions and allows for increased sensitivities. For instance, a quick rise in obscuration, without any associated rise in temperature, can be filtered out. Another benefit may be that these detectors use algorithms to process the analog values from all of the sensors. The conditions for reporting an alarm can then be based upon a combination of inputs from each sensing element, which further increases reliability by enhancing stability, sensitivity, or both.

MULTIDETECTOR COMPARISON

As smoke flows across a ceiling, it tends to affect more than a single detector. Multidetector comparisons make use of this trend. Affected detectors analyze adjacent detector prealarm conditions. Alarms are initiated when the prealarm conditions of adjacent detectors indicate a similar rise in the associated value. Similar to the detectors that compare profiles, these detectors can compare multiple locations and eliminate local spikes caused by an insect or radio frequency interference. This allows decreased alarm thresholds, faster detection times, and greater system stability.

OTHER FEATURES

Powerful system processors allow additional features, such as:

- Automatic Addressing: detectors automatically determine an independent address and integrate it into the system.
- Setting of Prealarms: one or more prealarms can be set.
- Detector Memory: detectors can store a variety of information including the rate of environmental compensation, last maintenance date, and analog signal for last alarm.
- Intelligent Notification: notification devices can be given discrete addresses to allow a single circuit to cover multiple independent notification zones. This also allows individual notification device testing.

Intelligent fire alarm systems can provide additional information to the control equipment and ultimately to the user. Each building layout and environment is unique, and application of these systems should be carefully evaluated to provide the best approach. Since analog detectors can compare conditions with known values and provide increased information, this technology provides many enhancements to today's systems.

Intelligent detectors will likely become the typical or standard detector for many applications. This will be due, in part, to the cost of these detectors becoming comparable to that of typical detectors. Currently, several intelligent devices are only slightly more costly than that of standard devices. As the cost of intelligent technology decreases, more and more of these devices will be used in fire alarm systems.

Finally, it is important to note that all detectors, whether combination and/or intelligent, require maintenance to be effective. Even with all of the new technology, maintenance programs for detectors and fire alarm systems should be viewed as one of the most important aspects of fire alarm systems.

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REFERENCES

1 *Training Manual On Fire Alarm Systems*, National Electrical Manufacturers Association, Washington, DC, 1992.

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