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Fire detectors and their connection suitable for application in residential, commercial or industrial buildings

Abstract. *Safety and security are currently highly resolved issues. One type of security is fire protection, which is solved in one of the options by applying fire detectors, which are part of the fire detection and alarm system. Fire detectors' main task is protecting people's lives and health and the safety of various assets through timely detection of fire threats with the subsequent performance of given measures. In addition to the types of fire detectors, the article also deals with the principle of their connection to the system.*

Streszczenie. *Bezpieczeństwo i ochrona to obecnie kwestie wysoce rozwiązane. Jednym z rodzajów zabezpieczeń jest ochrona przeciwpożarowa, która w jednym z wariantów jest rozwiązywana poprzez zastosowanie czujek pożarowych, wchodzących w skład systemu wykrywania i sygnalizacji pożaru. Głównym zadaniem czujek pożarowych jest ochrona życia i zdrowia ludzi oraz bezpieczeństwo różnorodnych dóbr poprzez terminowe wykrycie zagrożeń pożarowych i późniejsze podjęcie odpowiednich działań. Oprócz rodzajów czujek pożarowych w artykule omówiono także zasadę ich podłączenia do systemu. (**Detektory pożarowe i ich podłączenie przeznaczone do stosowania w budynkach mieszkalnych, komercyjnych i przemysłowych**)*

Keywords: Fire Safety; Fire Detectors; Smoke
Słowa kluczowe: bezpieczeństwo przeciwpożarowe; czujki pożarowe; palić

Introduction

Fire protection, as one of the oldest types of security, has continuously transformed to its current form. [1] At first, it was dealt with only from the point of view of fire protection of residences [2], social spaces [3], and commercial and industrial buildings [4], and nowadays, it is found in almost every sphere. [5] In the first chapter, the article focuses on a general description of fire protection. The following chapter deals with the central fire protection system – fire detector and alarm system. The next chapter deals with fire protection detectors, which can be divided according to the relevant criteria. The last chapter is about the connection of fire detectors to fire detectors and alarms system, where specific connection types are described.

The article's primary goal is to inform the readers about the possible types of fire detectors according to the given criteria and their connection method, which is suitable for application in residential, commercial or industrial buildings.

1 Fire safety

Fire protection is a set of methods, activities, material-technical and personnel security, the aim of which is to ensure conditions for the protection of life and health of natural persons, animals, property and the environment from fires, as well as to define the competence of public administration bodies and fire brigades in this area. The security system used as part of the fire protection of buildings is called a fire detector and alarm system. [6]

2 Fire detector and alarm system

A fire detector and alarm system (FDAS) is a dedicated fire safety device that ensures early fire alarms with the help of detectors.

The FDAS comprises a control panel, fire detectors, a fire alarm device, a device for transmission of malfunction reports, a control unit of automatic fire protection device and a power supply device.

A control panel is a central unit that gathers information from the connected detectors, which, according to the settings, process and respond to them with an appropriate response. Fire detectors are connected to the FDAS control panel at the input. The FDAS control centre is tasked with processing the input signal from the fire detectors and giving the signal to the output devices, i.e., signalling the occurrence of a fire in a guarded area and transferring information to the fire rescue service. At the same time, he must carry out several measures (e.g. unblocking escape routes, opening smoke dampers, disconnecting various production equipment, etc.). [7]

3. Fire detectors

Fire detectors are devices designed to monitor, measure and evaluate changes in physical parameters accompanying the occurrence of a fire. They contain evaluation circuits that decide whether the relevant parameter exceeds the permissible limit. Fire detectors are also used to identify and locate a fire at its origin and development stage. Alarms of fire generate an output electrical signal:

- automatically (automatic fire detector) - reaction to the occurrence or change of physical parameters without human intervention,
- activation by a given person (push-button fire detector) - report of the occurrence of a fire by a person identifying the alarm condition. [8]

Fire detectors can be divided according to 6 criteria:

- physical quantity,
- location in which the detectors evaluate the fire parameters,
- method of evacuation of changes in the monitored physical parameters,
- nullability,
- type of transfer,
- reaction time delay.

3.1 Physical quantity

This criterion divides detectors into nine groups: smoke detectors, flame emission detectors and temperature detectors, gas detectors, suction detectors, multisensor detectors, carbon monoxide fire detectors, interactive detectors and special detectors.

Smoke detectors react to a change in chemical composition. In this case, it can be ionization and optical smoke detectors. Ionization smoke detector – measurement of the change in quiescent current between two electrodes in the environment of the measured chamber. The more ionized the space, the better it conducts electricity. The optical smoke detector is based on the principle of smoke

entering the evaluation chamber. The detector reacts to smoke by lighting the LED and switching the relay. Smoke is only detected if it "hits" the sensor directly. The alarm will end only after the detection space in the smoke sensor has been "cleaned".

Fig. 1 – Smoke detector [9]

Flame emission detectors are based on response to spectrum change. Infrared flame detectors and ultraviolet flame detectors belong to this category.

Fig. 2 - Flame emission detector [10]

The temperature detector reacts to a change in temperature. This section includes point temperature detectors, linear temperature detectors, and thermostatic and thermodifferential detectors. The point temperature detector evaluates maximum and differential values based on temperature measurements with two thermistors. The linear temperature detector detects local differences in temperature and the density and refractive index of the air under the room's ceiling due to temperature fluctuations. The thermostatic temperature detector monitors the condition and reacts to a change in temperature by exceeding the specified fixed limit. The thermodifferential temperature detector monitors the condition and reacts to the rate of temperature increase over a specific time.

Fig. 3 – Temperature detector [11]

The gas detector reacts to an increased concentration of a gaseous substance in the environment.

The suction detector reacts to a change in pressure.

Multi-sensor detector combination of fire detectors (e.g. smoke and gas detector).

The carbon monoxide gas detector reacts to the presence of carbon monoxide.

Fig. 4 – Carbon monoxide detector [12]

Interactive detectors - interaction with other detectors or the environment.

Special detectors – e.g. based on the ultrasonic principle.

3.2 Location in which the detectors evaluate the fire parameters

According to this criterion, detectors can be divided into point detectors, multi-point detectors and linear detectors. Point detectors monitor changes in physical parameters in one place. It is the most widely used type for temperature, optical and flame fire detectors. A multi-point fire detector monitors changes in physical parameters in two or more locations. A linear fire detector monitors changes in a specific space or section. The reaction to the phenomenon is sensed near the continuous line - it detects a weakening of the intensity of the infrared radiation of the beam between the transmitter and the receiver.

3.3 Method of evacuation of changes in the monitored physical parameters

According to this criterion, fire detectors can be divided into five types: static, incremental, differential, combined and intelligent. The static fire detector reacts to exceeding the set limit value. The incremental fire detector reacts to exceeding the rate of change. The differential fire detector reacts to exceeding the change difference. The combined fire detector integrates the effects of static and incremental evaluation. The intelligent fire detector compares the measured values with information from other detectors in the assessed area.

3.4 Nullability

This criterion determines how the fire detector can reset to its original state in the event of an alarm. Five types of fire detectors can be included in this criterion: self-resettable, remotely resettable, locally resettable, non-resettable with replaceable elements (for example, batteries) and non-resettable without replaceable elements.

3.5 Type of transfer

Within this criterion, fire detectors can be divided into three types: two-state, multi-state, and analogue fire detectors. The two-state fire detector determines only two states - peace and alarm. The multi-state fire detector

determines several functional states, such as malfunction, test, etc.

3.6 Reaction time delay

The criterion determines the division of fire detectors into two groups: fire detectors without delay and fire detectors with delay. Fire detectors react without delay immediately after exceeding the limit value of the monitored parameter. Alarms with a delay react only after exceeding the limit value of the parameter, which lasts a specific time.

4 Connection of fire detectors

The FDAS topology can be implemented via line connection or circular connection. Lines within FDAS can be:

- reporting line – a transmission path that connects several elements of the reporting line that have a separate display on the control panel,
- fire loop – a line connecting a non-addressable fire detector or a group of these detectors with the corresponding input of the EPS control panel,
- fire line – line connecting the components of the addressable FDAS system with the relevant central FDAS.

As part of the circular connection, it involves isolators, which disconnect the line between the isolators in the event of a short circuit and operate the remaining parts as two separate lines. An example of a short circuit within a circular connection and its subsequent division into two separate lines is shown in Figure 5.

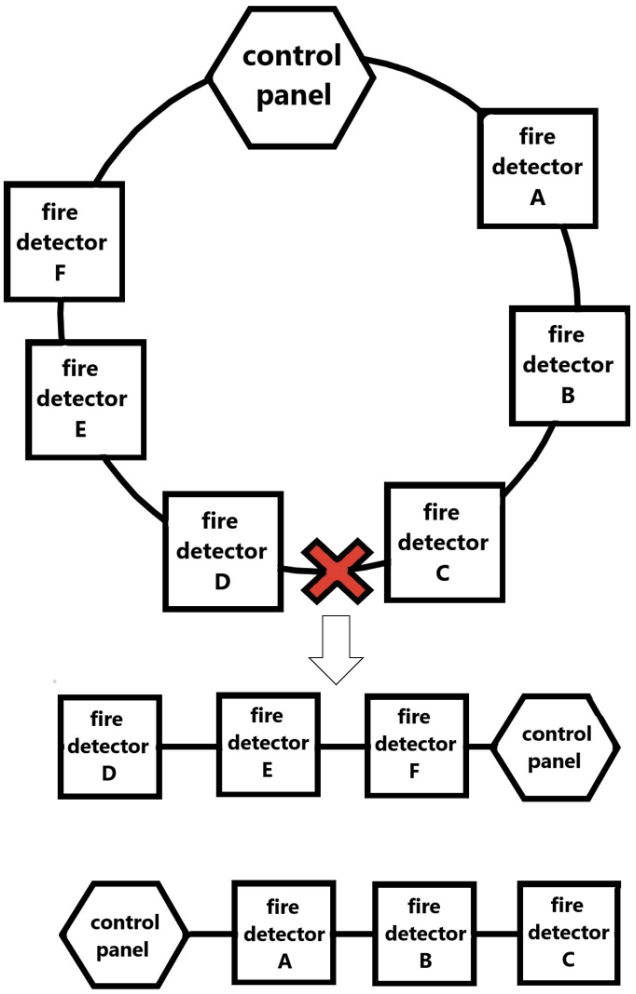

Fig. 5 – Circular and line connection of fire detectors [author]

Fire detectors in FDAS can be connected primarily by conventional connection with collective addressing or addressable connection with individual addressing.

4.1 Conventional connection with collective addressing

Within a conventional connection with a collective addressing system, the FDAS control panel cannot distinguish the fire detector from which the signal is coming; it will only report a fire on the entire line of detectors. Detectors that transmit the measured value to the control panel cannot be used for non-addressed fire detectors.

Checking the serviceability of a line with collective addressing is usually done by one of these two methods: checking the quiescent current of the reporting line or checking the pulses of the active terminator. Control of the quiescent current of the reporting line refers to the use of a terminating resistor so that the sum of the numerous fire detector currents and the current flowing through the terminating resistor is within the prescribed quiescent state tolerance. Control of the pulses of the active terminating member is used in the event that an active terminating member is connected at the end of the reporting line, which emits pulses of a certain length and current size. The FDAS control panel checks this signal and reports an error when the line is interrupted.

Transmission of the "Fire" signal to the FDAS control panel is usually carried out by one of the following two methods: evaluation of current changes on the reporting line or evaluation of voltage changes on the reporting line. This second method is used in most FDAS as the fire detector increases the current on the line to such a value that the voltage on the reporting line drops due to the non-zero impedance of the source.

4.2 Addressable connection with individual addressing

For larger objects, a connection with collective addressing is usually not enough because a large number of lines would have to be installed. Therefore, a system with individual addressing is used, where the FDAS control panel can determine the specific fire detector that reports the fire. This type of system is divided into systems with serial addressing and systems with parallel addressing.

Typical for serial addressing systems are:

- the state of the detectors is transmitted to the FDAS control panel in cycles,
- at the beginning, the FDAS control panel sets all detectors on the line to the initial position; when all series switches are opened - fire detectors are powered by built-in capacitors, and gradually, the switches are switched and the capacitors are charged,
- the system is sensitive to interference.

Systems with parallel addressing are typical for:

- the basis is digital communication between the control panel and the detector in the form of current or voltage changes on the reporting line,
- the FDAS control panel communicates with the detector by sending the address of the detector and other signals,
- all fire detectors decode and receive only the correct signal that is sent by the control panel and respond to it with their determined signal, which contains all the necessary information for the control panel.

Conclusion

As the main threat to fire protection, fire is a great enemy of society, which tries to eliminate it during the entire development of society. It is necessary to deal with this issue constantly. The article focused on categorising fire detectors and their connection method to electrical fire

signalling. The first chapter described fire protection in general, followed by another chapter regarding electrical fire signalling, where its meaning, principle, main tasks and activities were described. The following chapter dealt with the main issue itself – fire alarms. These were divided based on six essential criteria: physical quantity, location in which the fire detectors evaluate the fire parameters, evacuation method of changes in the monitored physical parameters, nullability, type of transfer and reaction time delay. The last chapter described the methods of connecting fire detectors to electrical fire signalling, where the individual connection methods were defined. In general, the main task of the article was to inform the public about the possible methods of fire detectors and how they are connected.

The limit of the article is the possibility of multiple categorisations of fire detectors from other possible categories according to other parameters.

The plan for the future is to evaluate the efficiency of connecting specific fire detectors to electrical fire signalling.

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