Analysis of the Inertial Parameters of Fire Detectors

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Abstract: **The article "Analysis of the Inertial Parameters of Fire Detectors" is devoted to examination of different parameters of fire detectors, as well as to the research of operation principles of fire detector and its construction solution. Parameters and construction peculiarities of smoke, heat, flame and gas detectors are described in the article. Special attention is paid to flame detection principles of different detectors. For more convenient perception of the material, the description of fire detectors is given in logical sequence, on the basis of detector classification according to fire detection factor. In the practical part of the article given comparison of different smoke and heat detectors is made. While burning different kinds of fuel, the time of detectors' reaction is recorded. In the end of the article the conclusions on practical part are given.**

Keywords: **fire detector, smoke detectors, heat detectors, signal transmission, state standard, reaction time.**

I. Fire Detector

Fire detector is a component of an automatic fire protection signal system that includes at least one sensor, continuously or in definite time interval controlling at least one physical or chemical parameter, connected with process of burning.

Usually, fire detectors are divided into two basic groups: manual and automatic alarm signal producers (see Fig.1). Manual alarm signal producers are placed at the exits or along evacuation ways, as required by Latvia standard LVS CEN/TS 54-14. In many cases it looks like a red button on the wall. In emergency situation, a person should press this button, but it can be too late, when somebody notices fire burning or clouds of smoke.[17]

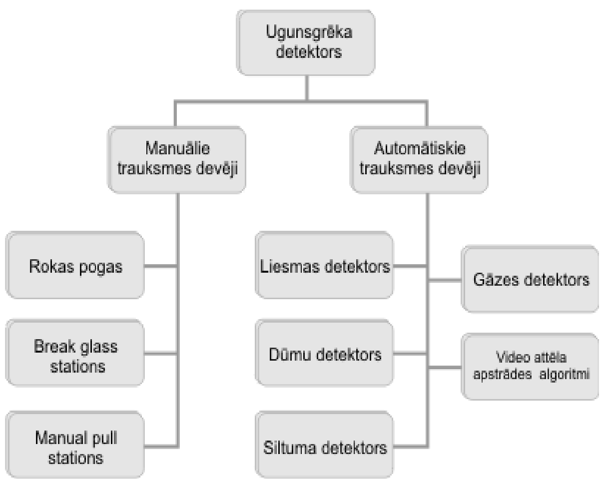

Fig.1 Initial classification of fire detectors

Nowadays, automatic fire detectors are used to detect fire on the initial stages. They are in controlling regime 24 hours a day without any human interference. Automatic fire detectors can be divided into several sub-types: smoke, fire, heat, video, carbon monoxide detectors and others. There exist point detectors, which are installed in a definite place and have definite range of operation. There exist linear detectors, which consist of a transmitter and a receiver and rely on laser technologies. They form invisible for people infrared „barrier" with the length of direct visibility 100 and more metres.

Depending on the possibilities of restarting, automatic fire detectors can be divided into three sub-types.

- „Return" detectors or detectors with the possibility of restarting are the ones that can return to controlling condition without replacement of any key parts or details, with the condition that the factors, having caused activisation of the detector, have been removed.
    - Detectors with automatic start-up – the detectors that are able to return to controlling condition themselves.
    - Remote controlled detectors – the detectors that are returned to controlling condition with the help of remote control signal.
    - Detectors with manual switching over – the detectors, that are returned to controlling condition by manual switching over.
- Detectors with disposable elements – the detectors that can be repeatedly set to controlling condition only after replacing some key parts or details.
- Detectors without the possibility of restarting.

According to the type of signal transmission automatic fire detectors can be divided into:

- Dual position detectors with one output, which transmits either «peace» signals or alarm signals.
- Multi-position detectors with one output, through which possible detector positions are transmitted: peace position, alarm position, cable break, defects, etc.
- Analogous detectors that continuously transmit signals about the condition of controlled parameters to control panel.

II. Comparison of Different State Standards

The time, during which fire detector should detect a fire ignition source, is one of the most important and hardly predictable parameters of any type of fire detectors. There exist several techniques of forecasting the parameter given, but no one of them is ideal so far. Future engineers from different leading universities in the fire security field propose their own approaches and methods of calculating fire detector reaction time. That is why every country in the world has its own normative base, where minimal requirements for fire detector are indicated. In the paper the paragraphs of national standards of three countries (USA, Russia, Latvia) concerning inertial parameters of fire detectors are compared.

A. USA state standard NFPA 72 - 2007

NFPA 72 (National Fire Protection Association) is the American fire security signalling system standard, which was last amended in 2007. This standard was elaborated on the basis of technologically managed and scientifically elaborated changes with the aim to improve evacuation time parameters and safety of the system. It is much said in the standard about mass communication systems, the instructions are given about how to evacuate people from buildings quickly and safely in dangerous and emergency situations, for example, during fires or terrorist attacks, accidents connected with dangerous biological or chemical substances, accidents or natural disasters. Also, additional requirements are given, as concerns modern technologies, including smoke and flame detection equipment after video image processing and multi-sensor equipment with fire-extinguishing functions, requirements for fire detectors placement while burning different materials are given, fire security requirements for household appliances are given. Altogether, USA state fire security standard consists of 537 pages [19].

B. Russia's State Standard ГОСТ 53325 – 2009

ГОСТ 53325 – 2009 „Техника пожарная. Технические средства пожарной автоматики. Общие технические требования. Методы испытаний." („Fire techniques. Means of fire automatics. The general technical requirements. Test methods.") is the fire security standard of the Russian Federation. The requirements of the standard concern fire security and fire-extinguishing automatic technical means that are used in the territory of Russia, as well as define general technical requirements for fire security equipment and its testing methods. In this document testing methods for fire detectors are described, as well as their parameters and recommendations for their placement in premises. Also, all the necessary activities for fire detector maintenance are described. Altogether, Russia's state fire security standard consists of 138 pages [21].

C. Latvian State Standard LVS/CEN TS 54-xx: 2005

European Committee for Standardization (CEN) was founded in 1961. European standard EN was accepted by CEN with the right to use it as identical state national standard. The aim of it was to liquidate conflicting requirements in European countries (only CEN members). EN standard consists of 27 parts. Each EN part is devoted to definite theme, for example, EN 54-7 Fire detection and fire signalling systems. Smoke detectors. Each part has its number. In the beginning there is Fire Security standard code EN 54 and after hyphen there goes the number of a part. According to CEN/CENELEC general position the following countries are obliged to introduce this standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, the Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom. From 2005 it became also Latvian national standard.

In accordance to the theme given, we are interested only in those parts of EN standard, where the requirements of fire detectors are described: LVS EN 54-5 – heat detectors; LVS EN 54-7 – smoke detectors; LVS EN 54-10 – flame detectors; LVS EN 54-12 – smoke linear detectors; LVS EN 54-20 – aspiration smoke detectors; LVS EN 54-22 – heat linear detectors.

D. Comparison of Different State Standards

Beginning with 20th century, to ensure people's safety and keep their property, humans pay more and more attention to technical safety means. To ensure fire protection, leading world's universities elaborate new technologies and develop old ones in the sphere of security. That is why, to adjust and improve the normative base of different countries, there exist a developing trend to compare the standards of different states to define the most optimal solution for each definite point.

Let us look at national fire safety standards of three states and compare them. As the volume of the paper is limited, only the most important points will be compared and inconsistency of some documents will be examined.

a. LVS EN 54-5 Heat Detectors - Point Detectors

NFPA 72:

- In this standard all the necessary documentation that heat detectors should have is indicated. This documentation can include installation instructions, technical data and specifications, including temperature parameters, sensitivity and RTI, defined by manufacturer. Standard includes only minimal allowed parameters values and methods of detector testing to acquire a certificate. If the product does not correspond to any of standard article, it cannot be used on the territory of the USA.
- All heat detectors, linear as well as point detectors, should be marked with colour according to the table below - standard Table *5.6.2.1.1.* (see Table 1).
- The document describes the places of heat detectors in premises, but there is no precise definition of minimal reaction time of heat detector[19]

TABLE 1

MARKING TABLE FOR HEAT DETECTORS [19]

Table 5.6.2.1.1 Temperature Classification for Heat-Sensing Fire Detectors

Temperature Classification	Temperature Rating Range		Maximum Ceiling Temperature		Color Code
	°C	°F	°C	°F	
Low*	39–57	100–134	28	80	Uncolored
Ordinary	58–79	135–174	47	115	Uncolored
Intermediate	80–121	175–249	69	155	White
High	122–162	250–324	111	230	Blue
Extra high	163–204	325–399	152	305	Red
Very extra high	205–259	400–499	194	380	Green
Ultra high	260–302	500–575	249	480	Orange

LVS EN 54-5:

- To indicate start-up temperature of a heat detector, each detector should be marked with letter code according to the table given. Similar to NFPA standard, all the documentation necessary for heat detector is indicated, but EN 54-5 does not say anything about RTI parameter. Instead of it time constant T is used.
- In EN 54-5 colour marking is not required, only code marking according to Table 2. Each detector should have the following information label: a) standard number EN 54-5, b) detector class (A1; A1P; etc.). If a detector, independent from its working principle,

has some regulated parameters, for example, sensitivity or start-up temperature, it is indicated with P letter in the end of a detector's name (see table 2).

TABLE 2
CLASSIFICATION OF HEAT DETECTORS ACCORDING TO TEMPERATURE [13]

Detector Classification Temperatures (EN54-5 Table 1 in 4.2)

Detector Class	Typ. App. Temp °C	Max App. Temp °C	Min Static Resp Temp °C	Max Static Resp Temp °C
A1	25	50	54	65
A2	25	50	54	70
B	40	65	69	85
C	55	80	84	100
D	70	95	99	115
E	85	110	114	130
F	100	125	129	145
G	115	140	144	160

ГОСТ 53325 – 2009:

- Marking and classification of heat detectors is absolutely identical to EN 54-5 standard.
- In the standard minimal and maximal heat detector reaction time is strictly defined. Depending on detector class and its working principles, reaction time for maximal, discriminative and maximum-discriminative detectors is defined in table 3 [21].

b. LVS EN 54-7 Smoke Point Detectors

NFPA 72:

- Smoke detectors should be marked with nominal sensitivity value and allowed sensitive element blackout in per cents.
- If smoke detector has parameters with calibration possibility, there should obligatory be possibility to set manufacturer's settings. Nothing is said about it in EN 54-7 and ГОСТ 53325 standards.
- In all three standards smoke detector testing methods for different conditions are described in detail. [19]

LVS EN 54-7:

- Each smoke detector should have red optical indicator to have the possibility to define the detector that have set the alarm signal quickly and without mistakes.
- Marking of smoke detectors is similar to heat detectors.
- According to standard requirements, smoke detectors should have sufficient amount of technical information and specifications, as well as installation manual and technical maintenance regulations to correctly install the detector and check its functionality. [14]

TABLE 3

Speed of temperature rise, $\frac{°C}{min}$	Detector starting time, s	
	Minimum	Maximum
Maximal heat detectors, class A1		
1	1740	2420
3	580	820
5	348	500
10	174	260
20	87	140
30	58	100
Maximal heat detectors, classes A2, B, C, D, E, F, G		
1	1740	2760
3	580	960
5	348	600
10	174	329
20	87	192
30	58	144
Discriminative and maximum-discriminative detectors		
5	120	500
10	60	242
20	30	130
30	20	100

ГОСТ 53325 – 2009:

- Fire smoke detectors should not set alarm or damage signal in case the radiation of radiating element stops for less than 0.1 – 1 s. LVS EN 54-7 and NFPA 72 standards lack such requirements.
- Smoke detectors should set an alarm signal if the radiation of radiating element is stopped for more than 2 seconds. LVS EN 54-7 and NFPA 72 standards lack such requirements. [21]

c. LVS EN 54-10 Flame Detectors.

NFPA 72 and LVS EN 54-7:

- In European and American state standards there is a detailed description of flame detectors testing methods. The distance within which a fire detector should distinguish flame from background interference is regulated. Recommendations about the more efficient flame detectors in premises are given. There is no flame detector classification.

ГОСТ 53325 – 2009:

- Standards strictly define the classification of flame detectors. Flame detectors are classified according to maximal range of action when a detector is able to distinguish flame factors from background interference during testing time in a definite period of time, but no more than 30 s.
- For background illumination of detector's sensitive element fluorescent lamps are usually used. Maximal illumination should be not less than 2500 luces for

detector to preserve its working ability without setting false alarm signals. [21]

d. LVS EN 54-12 Linear Smoke Detectors.

In all three standards detector testing methods in different conditions are described in detail. In all three standards there are articles, where the signal that should be received from detector, is described. For example, if the ray of light is completely blocked for a period of time longer than 2 seconds, detector should transmit damage signal, not an alarm signal, as smoke cannot cover a ray of light for 100% for a long time. As the main detector parameter connection between smoke and clean air concentration that a detector can distinguish is accepted. Detectors are classified according to their sensitivity. In no standard minimal detector reaction time is directly defined.

e. Summary

In each of three standards testing methods for every detector type in different conditions are described in detail. Detectors of all types are tested for different kinds of resistance, lifespan, instability of parameters that can appear during operation. But standard testing descriptions do not mention minimal reaction time for any of dangerous factors. Requirements for detector marking are described in detail. In each standard there is own detector classification. On the whole, requirements specified in standards for fire detectors are similar.

Several experiments have been made with different heat and smoke detectors to define their reaction time for the presence of different dangerous factors. Operational integrity of fire detectors ensures object protection, as well as defines the operational integrity of the whole system. Functional testing of fire detectors is an obligatory procedure before their installation, commissioning and annual maintenance.

Testing of different types of fire detectors was performed – how quickly each detector is able to detect dangerous factors in A and B class fires.

According to Latvia Ministry Cabinet regulations Nr. 82 «Regulations of fire safety», depending on the material burning, fires can be divided into such classes:

A class – fires, when hard materials, usually of an organic origin, burn and live coal is formed;

B class – fires, when liquids or fluxing hard materials burn;

C class – fires with gases burning;

D class – fires with metal burning.

Different types of fire detectors available in Latvia's shops have been taken to clarify how quickly certain detector type is able to detect a source of ignition of A or B class fire.

On the whole, 8 detectors were bought:

Smoke: EA318-2; AH-0311-2,3,4 ;

Smoke analogous: SD-436; NB-739B1

Heat: IP 103-5/4; NB323-2; NB323-4;

Combined: NB338-2H

Unfortunately, the choice of fire detectors in Latvia is limited because of various reasons, for example, some types of detectors (aspiration, ray, etc.) can only be specially ordered, as their cost is from 100 to several thousands of lats and it is not profitable for sellers to store them.

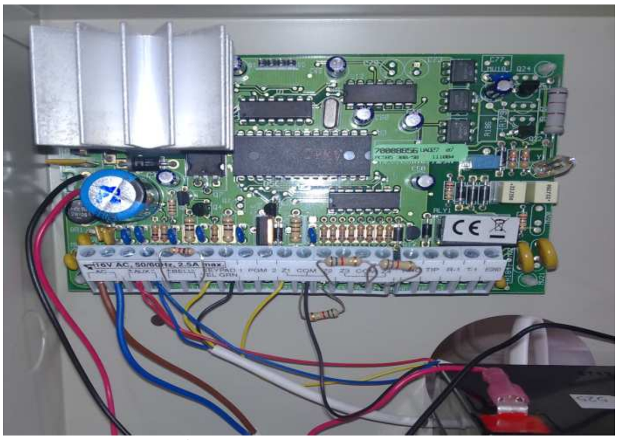

Fig. 2. Locking scheme of security panel DSC PC585.

Specially equipped camera has been used for making the experiment. It is in Meza Str. 1-7, in Room 10. During testing each detector in its turn has been attached to the ceiling at the same height of 2.5 m above the floor directly above imitating source of ignition. After that some fuel was ignited. At once, after the ignition the time marking with the help of chronometer has been initiated. When the detector sets the alarm signal, time was recorded in the table. To record detector's alarm condition, security panel DSC PC585 (see Fig. 2), as well as separate built-in detector indication have been used.

III. Testing A Class Fires

According to definition, A class fires are the ones with hard materials, usually of organic origin, burning and living coal forming. Evidently, at such type of fires a lot of smoke is produced, that is why we can consider, that it is worth using smoke detectors for detecting such type of fire, as there exist a great possibility that smoke will appear. Different plastic materials, rubber, textile, wood, paper and other materials can be used as fuel. These materials are met almost in every house or at working place. Also, it is evident that it is not worth trying to use heat detectors while burning smoking substances, as they eliminate too little heat.

To acquire qualitative experiment results and get the possibility to compare them, identical conditions have been provided. Each detector was attached to the ceiling at the same height of 2.5 m above the floor. To get to know the response time of a detector, fire load was gradually changed from lesser to bigger. Ordinary A4 format paper sheets were used as fuel. The weight of each sheet is 0.0048 kg or 4.8 g. So, increasing the number of sheets, we also increase the mass of paper, as well as the widths of ignition source. Sheets are placed close to each other, before that pressing them together. After igniting fuel mixture, time marking begins and after a detector sets an alarm signal, time is recorded in a table (see Table 4). The time, when the burning process finishes and only waste remain, is also recorded in the table. Evidently, when fuel ends, smoke also finishes emitting, but air flows with smoke particles still rise up to the ceiling, so each experiment can be finished only in 5 minutes or 300 seconds, not already after the start of the burning process. To clear the air from smoke particles, for them not to interfere with each other in the next experiment, the contaminated air is removed from testing camera through special filter with the help of a pump.

In the end, the following results have been obtained:

TABLE 4

A CLASS FIRE TESTING RESULTS

Fuel - paper		Time of detector reaction t, s					Full burn out time, s	Width of source of ignition m^2
Number of pages	g	EA3 182	NB 338 2H	AH 031 1	SD4 36	NB 739 B1		
3	14,4	-	-	-	-	-	65	0.027
5	24	-	-	-	-	-	76	0.04
10	48	-	-	-	225	-	83	0.064
15	72	-	-	-	185	-	97	0.123
20	96	113	107	-	123	-	105	0.14
30	144	80	73	134	82	-	119	0.193
50	240	61	57	109	66	-	137	0.25

Evidently, to start smoke detector up in the conditions given, it is necessary to burn not less than 50 g of paper. In its turn, to start the biggest part of detectors examined, it was necessary to burn about 100 g of paper. One can also see, that one autonomous detector did not start up at all because of unknown reason. According to the data acquired, we can show detector's reaction time depending on the amount of fuel burnt (see Fig. 3).

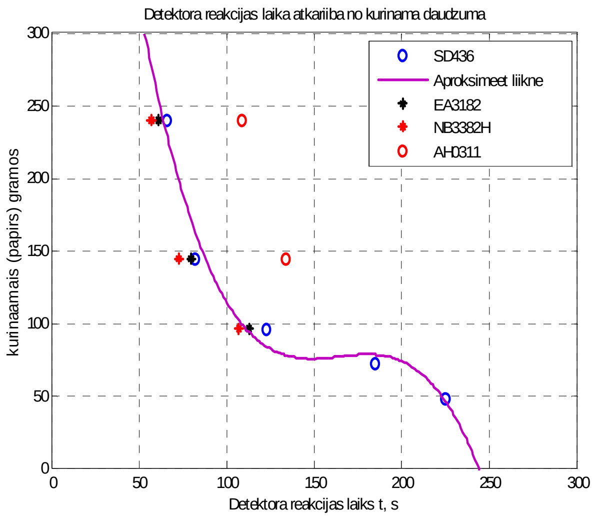

Fig. 3. Dependence of the reaction time of fire detector on the volume of fuel.

a. Testing B Class Fires

According to the definition, B class fires are fires with liquids or melting hard materials burning. Seeing over a living or working place of an average person, liquids are more often met. These liquids can be ignited. They can be gasoline, motor fuel, petroleum, spirits, motor oils, different household chemicals, etc. Usually this type of fires does not have smoldering processes, during which smoke is emitted, but burning substances burst into flame at once and produce a great amount of heat. That is why we can consider, that for this type of fires it is worth using flame detectors or heat detectors, to detect flames or warm air rising up to the ceiling. Only heat detectors have been at our service, so only heat detectors and one combined detector have been used for testing.

To acquire qualitative experiment results and get the possibility to compare them, identical conditions have been provided. To start up a heat detector, sufficient amount of heat is necessary. It is also important for heat flow to reach the detector. As the size of the testing camera, used for the experiment, was big enough, it was necessary to burn a great amount of liquid fuel. It was very dangerous, as testing camera was not suitable for high temperatures and the budget was limited. So a decision was made to attach detectors closer to the source of ignition, approximately 1.55 m above it. Spirit was used as fuel. But, as it burns very fast and the amount of spirit was also limited, a decision was made to use spirit saturated paper. For each experiment 10 - 50 sheets of A4 format paper and 10-20 ml of spirit were used.

Similar to the previous experiment, to get to know the response time of a detector, fire load has been gradually changed from lesser to bigger. Pressed and spirit saturated A4 sheets of paper were placed close to each other and ignited. After the ignition of fuel mixture, time marking began and after the signal of the detector was received the time was recorded in the table (see Table 5). The time when burning process finishes and only waste remains is also recorded in the table. The following results have been obtained:

TABLE 5

B CLASS FIRE TESTING RESULTS

Fuel		Time of detector reaction t, s				Full burn out time, s
Number of pages	g	IP 103-5/4	NB323-2	NB323-4-12	NB338 -2H	
5	24	-	-	-	-	29
10	48	-	-	-	-	34
20	96	23	21	20	16	43
30	144	21	19	18	15	57
50	240	21	18	17	15	72

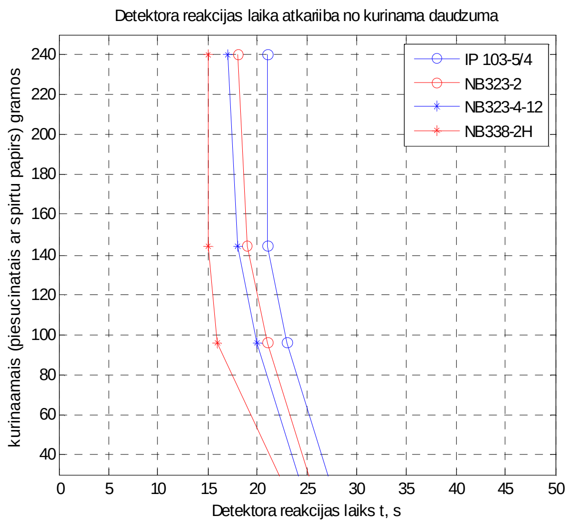

Fig. 4. Dependence of the reaction time of heat detector on the volume of fuel.

Evidently, to start up the heat detector in such conditions, it is necessary to burn not less than 100 g of spirit saturated paper. All heat detectors used, when burning definite amount of fuel, started working almost simultaneously. According to the data acquired, we can show detector's reaction time depending on the amount of fuel burnt (see Fig.4).

IV. CONCLUSIONS

Efficient Use of Fire Detectors

Having studied various literary sources and taking into account the accumulated experience in using fire detectors, it has been concluded that operation of smoke and heat detectors depends on air convection, which transfers hot gas and smoke from source to detector. Installation and placement of fire detectors should be based on the necessity to limit the time spent on the transfer of such air and with sufficient concentration of combustion products in the place where detectors are placed. On the whole, hot gases and smoke will concentrate in the highest part of premises, so smoke and heat detectors should be placed there.

As smoke and hot gas rise up from the ignition source, they mix up with cold air that comes into convection flow. As a consequence, with the height of premises growing, the width of the ignition source or fire load should be increased to start up smoke or heat detector. Up to a certain moment, this effect can be compensated by using a detector with higher sensitivity, but, in its turn, it leads to increase in the price of a detector.

Usually, to protect some premises, smoke or heat detectors are placed at a maximum allowed distance between them. In LVS CEN/TS 54-14 standard it is 5 m between heat detectors and 7.5 m between smoke detectors, but some local places can be protected by additional detectors. For example, systems with linear heat detectors are well appropriate for protecting power systems or cable network. In this case a detector should be placed closer to the place, where overheat or fire can appear, as much as possible.

Effectiveness of the automatic fire detection system is influenced by obstacles between heat or smoke detectors and combustion products. It is highly important that detectors were not placed too close to the obstacles for hot air flows. At the meeting point of the wall and the ceiling there is a so-called «empty space» where smoke or heat detection is not effective. Detection of carbon monoxide can be less effective if the gas is transferred with the help of diffusion.

As smoke and hot gas distribute horizontally, parallel to the ceiling, there is a freezing layer close to the ceiling. It excludes the possibility to place smoke and heat detectors so, that the sensitive element of a detector is placed at one level with the ceiling. This restriction can be less important in case of aspiration system, as the system actively draws in air samples.

Test Results

Analysing the testing results acquired, one can conclude that fire detector's reaction time depends on various factors: fire load, height of placement, environment conditions, ventilation, etc.

Experimentally it has been clarified, that fire load is a very important parameter for smoke detectors. The bigger amount of materials is burning, the bigger smoke it emits. But it is worth noting, that detector's reaction time is also influenced by its placement height. The higher the detector is placed, the longer air masses rise up to the ceiling, the longer is detector's reaction time.

Heat detectors show the same trend, as smoke detectors, but they are more affected by the height of placement. It is connected with the fact, that air flows cool while rising up and so they transfer less amount of heat to a detector.

Proposals

None of the standards analysed in the present paper contains clear specification on maximal allowed detector reaction time, but detector's range of operation is defined for premises up to and above 8 m high. For premises up to 8 m high range of operation for smoke detectors is 7.5 m, for heat detectors – 5 m, but it is not clear where these numbers are taken from. The authors of the paper think that it is necessary to introduce the requirements for fire detectors into standard. These requirements should reflect maximal allowed detector reaction time depending on possible fire load.

REFERENCES

[1] Фёдоров А.В., Членов А.Н., Лукьянченко А.А., Буцынская Т.А., Демёхин Ф.В. Системы и технические средства раннего обнаружения пожара: Монография.– М.: Академия ГПС МЧС России, 2009. – 160 с.

[2] А.Н. Членов, д.т.н., профессор. Современные тепловые пожарные извещатели: основные характеристики и особенности применения. Журнал Системы безопасности №1 (55), 2004.

[3] «Извещатель пожарный тепловой дифференциальный многоточечный ИП 102-2х2». Отчет о проведении испытаний. ИЦ ФГУ ВНИИПО МВД РФ (утв. 15.07.2002 г.).

[4] Извещатель пожарный дымовой оптико-электронный «ИПДЛ-52», Руководство по эксплуатации, ОАО «IVS сигналспецавтоматика», 26 стр.

[5] И.Г. Неплохов Аспирационные извещатели: классификация и характеристики "Систем Сенсор Фаир Детекторс", *Системы безопасности S&S", Groteck, №1, 2007.*

[6] М.В. Трубаева специалист технической поддержки ООО "ППП "КБ Прибор" – «Извещатели пламени – техническое обозрение», Журнал "Системы безопасности" № 4, 2009.

[7] А. А. Егоров Институт общей физики им. А.М. Прохорова РАН, «Систематика, принципы работы и области применения датчиков», Журнал радиоэлектроники № 3, 11 марта 2009 год.

[8] А.В. Фёдоров, Т.А. Буцынская, «Раннее обнаружение пожара техническими средствами пожарной сигнализации», Интернет-журнал 22 января 2009

[9] B. Uğur Töreyin, Yiğithan Dedeoğlu, Ug Uğur Güdükbay, A. Enis Çetin, „Computer vision based method for real-time fire and flame detection", 2005

[10] Nicholas True, University of California, San Diego, „Computer Vision Based Fire Detection", 6 pages.

[11] Fire Dynamics Tools – Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program, Washington, 11 chapter - ESTIMATING SMOKE DETECTOR RESPONSE TIME, 2004

[12] Fire Dynamics Tools – Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program, Washington, 12 chapter - ESTIMATING HEAT DETECTOR RESPONSE TIME, 2004

[13] LVS EN 54-5 Ugunsgrēka atklāšanas un ugunsgrēka trauksmes sistēmas. 5.daļa: Siltuma detektori. Punktveida detektori (11.04.2006. precizēts nosaukuma tulkojums)

[14] LVS EN 54-7 Ugunsgrēka atklāšanas un ugunsgrēka trauksmes sistēmas. 7.daļa: Dūmu detektori. Punktveida detektori, kuros izmanto izkliedētu gaismu, atstarotu gaismu vai jonizāciju.

[15] LVS EN 54-10 Ugunsgrēka atklāšanas un ugunsgrēka trauksmes sistēmas. 10.daļa: Liesmas detektori. Punktveida detektori (11.04.2006. precizēts nosaukuma tulkojums)

[16] LVS EN 54-12 Ugunsgrēka atklāšanas un ugunsgrēka trauksmes sistēmas. 12.daļa: Dūmu detektori. Lineārie detektori, kuros izmanto gaismas staru (11.04.2006 precizēts nosaukuma tulkojums)
[17] LVS CEN/TS 54-14 Ugunsgrēka uztveršanas un ugunsgrēka signalizācijas sistēmas. 14.daļa: Norādījumi plānošanai, projektēšanai, montāžai, nodošanai ekspluatācijā, lietošanai un uzturēšanai darba kārtībā
[18] LVS EN 54-20 Ugunsgrēka atklāšanas un ugunsgrēka trauksmes sistēmas. 20.daļa: Aspirācijas dūmu detektori.
[19] NFPA 72 National Fire Alarm Code 2002 Edition.
[20] US National fire alarm code NFPA 72 and European standarts in the EN54 series – assessment of compatinility. BreGlobal. 27 may 2010. 33pages
[21] Национальный стандарт Российской фелерации ГОСТ Р 53325-2009, Техника пожарная. Технические средства пожарной автоматики. 173 стр.
[22] Егоров А.А., Егоров М.А., Царева Ю.И. «Химические сенсоры: классификация, принцип работы, область применения» www.chemphys.edu.ru/pdf/2008-01-14-001.pdf
[23] Линейный тепловой пожарный извещатель (термокабель) PHSC ОАО «МГП СПЕЦАВТОМАТИКА». 12.02.2012. http://www.mgpspetsavtomatika.ru/prev/termokabel.html
[24] Оптоволоконный линейный извещатель пожара. ОАО «Армо-системы», 12.02.2012. - http://www.armosystems.ru/print/?id=1653&articles=1
[25] Stāsts par termoelektrisko efektu (Zeebeka efekts) http://en.wikipedia.org/wiki/Thermoelectric_effect
[26] Valsts ugunsdzēsības un glābšanas dienesta mājas lapa - http://www.vugd.gov.lv/lat/
[27] Flame Ionization Detectors: Applications and operations. Second Quarter 2009. www.specialtygasreport.com
[28] Gāzes analizatori ar termokatalītisko un elektroķīmisko mērīšanas principi. – http://knowkip.ucoz.ru/publ/teplotekhnicheskie_izmerenija/drugie_izmerenija/gazoanalizatory/5-1-0-14

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