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System of object display in conditions of smoke screening

Abstract. Paper presents results of investigations of increased visibility with help of electrooptical system APIS in a smoky environment in outdoor conditions. A comparative assessment of visibility in smoke with use of this system is given as well as posibility of the visibility increase with help of the APIS system is considered.
Keywords: smoke, visibility**.**

Fire alert and evacuation management systems are the one of the constituent elements of systems for fire safety in buildings. Arrangement of these systems is made in order to organize management and direct control over the process of evacuation. Fire notification in a building is provided taken into consideration the space planning and design solutions for buildings, lack of time to evacuate people, the qualitative composition of people flows and their preparedness for their own rescue.

There are five types of systems in the Republic of Belarus. They differ from each other by notification ways (sound, light, or voice), the presence of communication of the notification zone with the dispatcher, by order of warning, level of automation of systems control and possibility to implement plurality of principles of evacuation. The choice of the system type shall be based on the functional purpose of the building and one of the standard indicators (the area of the building's floor, capacity, number of floors).

To implement the functions of the analysis of the object, the operational delivery of the information about the fire or the presence of fire hazards, control the passage and the end of the evacuation and emergency situations the devices detecting the presence of people in the room should apply.

Application for these purposes of normal video cameras is complicated by the possible indoor smoke. The application of opto-electronic devices based on the method of sampling seems more promising. Such systems are also called active-pulse imaging systems (APIS). Such systems are commonly used in various branches of technology to improve the visibility mainly in fog conditions [1].

This paper presents the results of investigations of increased visibility with the help of electro-optical system APIS in a smoky environment in outdoor conditions. A comparative assessment of visibility in smoke with the use of this system, the lantern and the thermal imager is given and the possibility of increasing the visibility with the help of this system is considered.

Experimental Part

The effect of active pulse-vision systems is based on the pulse method of sensing and monitoring proposed by academician A. Lebedev in 1936. The essence of the method is as follows. The object of observation is illuminated by short light pulses whose duration is much less than the propagation of the light to the object and back. The object is observed in the optical device equipped with a quick-release which is opening in time with the sending of light pulses at a certain period of time. In the case where the time lag between the moment of light pulse and the valve opening is equal to twice the time required for the passage of light the distance to the object and back, the viewer will see only the object itself and a portion of the space surrounding it. The depth of this space is defined as by the time of the open state of the valve, and the duration of the light pulse. The implementation of this method requires a pulsed illuminator that generates a relatively short pulses of light – a laser emitter and image converter, and the electron-optical converter (EOC) can be used as it, equipped with a quick release. Schematic diagram of the developed vision system is shown in Figure 1 and the experimental model is shown in Figure 2. General specifications of the experimental model are given in Table 1.

Studies were carried out in a room with following dimensions: length – 33 m; width – 8 m; height in the center – 4 m. In the room for measuring the concentration of smoke optical density meter is placed (measuring range of the optical density 0,00 – 3,00 dB with an absolute error of

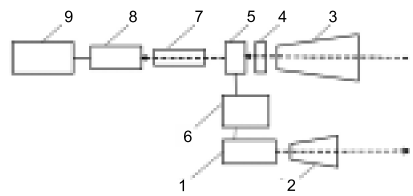

Fig. 1. The concept of optic electronic system for improving the visibility in smoke: 1 – laser illuminator; 2 – lens-shaper; 3 – receiving lens; 4 – optic filter; 5 – optoelectronic transducer (OET); 6 – electronic sampling in range unit; 7 – matching lens; 8 – video camera; 9 – LCD monitor

Fig. 2. The experimental model of optic electronic system for improving the visibility in smoke

Table 1. The main technical characteristics of the experimental model

System parameter	Value
The length of wave emission of the laser illuminator [nm]	850
Peak power of the laser radiation [W]	320
Pulse duration [ns]	~ 60
Pulse repetition frequency [Hz]	5000 – 10 000
Distance to the surveillance zone [m]: – minimum; – maximum	 10 500
Depth of field observations [m]: – minimum; – maximum	 15 120
Magnification, multiplicity	3
Viewing angle [deg]: – vertically; – horizontally	 6 20
Weight [kg]	2

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measurement not exceeding ± 0,02 dB). The meter was placed at a height of 1,5 m, which corresponds to the height of the optical axis of the test observations with the experimental model. Floor plan and placement of equipment and the seat of the fire are shown in Figure 3.

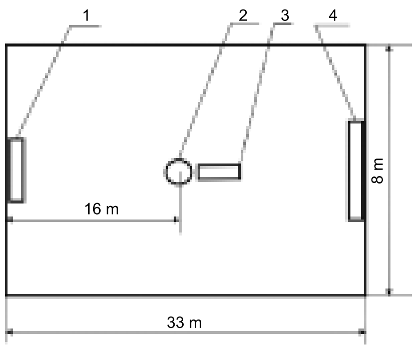

Fig. 3. Premise plan for fire tests of testing model: 1 – testing equipment; 2 – testing seat of fire; 3 – measuring equipment; 4 – the object of observation

As a fire tires (7 kg) were used, laid on a metal tray sizes 540 x 540 x 20 mm. A source of ignition is petrol, which was ignited by open flame. For the study of the developed system the technique of visually determining the range of visibility was used with the help of a guide-board, adapted to the conditions of the experiment. This technique was introduced by the International Commission on Illumination (CIE), recognized by the International Electrotechnical Commission (IEC, 1987), formally adopted by the World Meteorological Organization (WMO, 1993) as a method to determine the visibility of the atmosphere. Since the visual assessment of visibility depends on the individual abilities of perception and interpretation, as well as on the characteristics of the light source and the transmission coefficient, for the purpose of comparability of results of visual observations of visibility in a smoky environment by different observers uniform requirements were established for landmarks and for the observer's vision – observers who conduct visual observation of the visibility, must have visual acuity of 1.0 for each eye. As the visibility landmark the black-and-white square shield 0,40 x 1,20 m, was used, which has the form of four staggered cells.

For the development of method and taking into account the features of the application of the developed system as a means of stationary surveillance the man was used as additional landmark. To compare the effectiveness of the developed system were used special lantern and thermal imager FLIR ThermaCAM E300. Observations were recorded by the camera Canon A570 (7,2 M). Test fire seat was placed at a distance of 16 m from the point of the test equipment placement. Before each test, the room aired prior to the initial test conditions. The scheme of studies is shown in Figure 4.

The landmarks were placed on the same optical axis with the optical density meter. When conducting visual observations to determine (evaluate) visibility following requirements were carried out:

- the observer's eyes were on a level of test equipment placement;
- observers who conducted visual observations of visibility, had visual acuity of 1,0 in each eye.

The landmarks were placed at a distance of 27 m from the object of study. After the fire starting visual surveillance of the landmarks has begun. At a time when observers ceased to distinguish the landmark on the background, the meter reading of the specific optical density D_{gl} [dB/m] were recorded. At the same time as the visible landmark was that one which could be seen on the background at least as a contour; the invisible landmark was considered a landmark that is blended with the background.

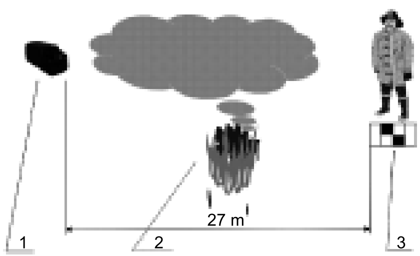

Fig. 4. Research diagram of optoelectronic system for improving the visibility in smoke: 1 – system studied; 2 – the seat of fire; 3 – landmarks

Furthermore, during the fire burning, meter readings of the specific optical density D_c [dB/m] at the time when the screen of the optoelectronic system stopped to recognize the landmarks were similarly recorded. The improving of the visibility is determined by formula:

$$\left(\frac{L_c}{L_{gl.}}\right) = \frac{D_{c.}}{D_{gl.}},$$

where:
L_c – the distance at which the landmarks were placed at the start of the study [m];
$L_{gl.}$ – meteorological visibility range (without usage of visibility improving system) [m].

Results

Comparative assessment of the visibility was performed according to the developed technique. Figure 5 shows images of a man's figure at a distance of 27 m, made by Canon A570 camera without backlight lamp (Fig. 5a), Canon A570 camera with illumination lamp (Fig. 5b), the thermal imager FLIR ThermaCAM E300 (Fig. 5c) and developed optoelectronic system (Fig. 5d) during rubber burning.

Images were obtained at a time when observers stopped to distinguish the land-

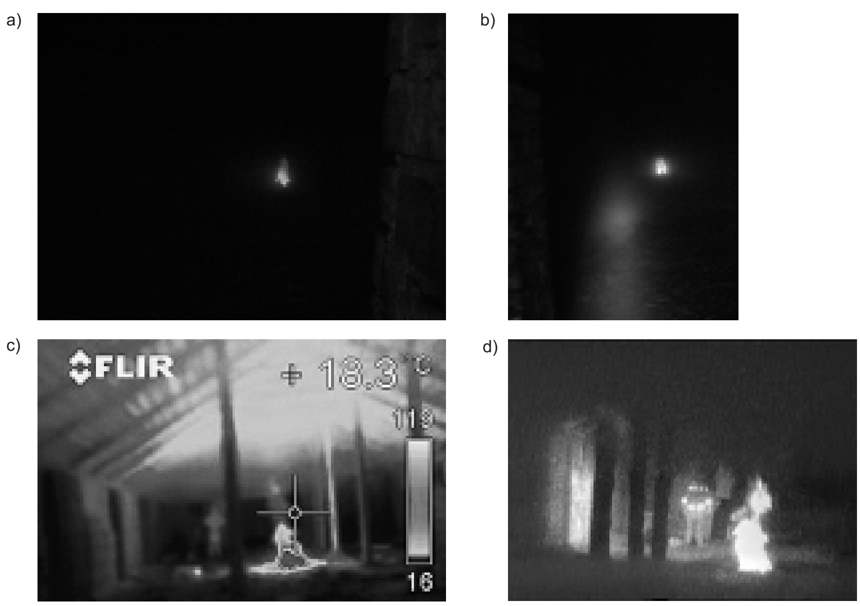

Fig. 5. Images made at rubber burning at the specific optical smoke density equal to 0,32 [dB / m]: a – Canon A570 camera without backlight lamp; b – Canon A570 camera with illumination lamp; c – thermal imager FLIR ThermaCAM E300; d – developed optoelectronic system

marks on the background, and are consistent with the meter reading of the specific optical density of smoke of 0,32 [dB/m]. The specific optical density of smoke at the time was recorded, when the screen of studied optoelectronic system wasn't able to recognize the parts of a man's figure, who has no retroreflective elements was 1,13 dB/m. Retroreflective elements on the clothing were no longer recognized when the specific optical density of smoke was equal to 1,44 dB/m. Quantitative indicators of the research are summarized in Table 2.

Table 2. The results of evaluation to improve visibility in smoke with the help of the studied optical-electronic system with burning rubber

Parameter	Value
Specific optical density of smoke at the loss of visibility by eye $D_{gl.}$ [dB/m]	0,32
Specific optical density of smoke at a loss of visibility of human body without retroreflective elements through a system D_c [dB/m]	1,13
Specific optical density of smoke when they lose sight of human body with sretroreflective elements through a system D_{1c} [dB/m]	1,44
Distance to the observed object L_c [m]	27
Metereologic visibility at smoke blanketing without retroreflective elements, $L_{gl.2}$ [m]	7,6
Metereologic visibility at smoke blanketing with retroreflective elements, $L_{gl.1}$ [m]	6
Improving of visibility in the application of the studied system $L_c/L_{gl.2}$ at landmark without retroreflective elements	3,53
Improving visibility in the application of the studied system $L_c/L_{1gl.2}$ at landmark with retroreflective elements	4,5

Conclusion

Above mentioned studies have shown the prospects of further research on the development of opto-electronic systems, which are based on the method of sampling and intended for visualization of objects in a smoky environment. The developed technique to study the electro-optical system for improving the visibility in smoke was able to make the comparative assessment of visibility in smoke with the help of this system, the lantern and a thermal imager and to compare the opportunities to increase the visibility with the help of this system. Studies have shown that in the conditions of rubber burning, improving the visibility while using this system in comparison with the naked eye with the landmark without retroreflective elements was 3,5 and with retroreflective elements – 4,5.

Literature

[1] A. Surykau, V. Petukhov, B. Gorobets. Basic methods and devices used and promising to improve the visibility during the emergency situations. Emergency situations: prevention and response, no 1 (29) 2011, the Republic of Belarus, Minsk.

Transforming the approach to achieving fire safety in the UK

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Table 1. Fire and Rescue Service fire prevention events – 2012/13

Campaigns and initiatives	Personnel Hours spent	Number of Visits
Fire Prevention campaigns and initiatives – Total	648,920	139,969
of which: Young firesetter, anti-social behaviour schemes and other youth diversion	223,223	25,644
of which: Other youth fire safety programmes	219,037	30,714

Table 2. Fire and Rescue Service Audits of premises to which the Regulatory Reform (Fire Safety) Order applies 2012/2013 (England)

Appendix 13. Fire Safety Audit scarried out by the Fireand Rescue Seivice in Englandat 31 March 2013										
	Audits/Inspections			Informal notificatic	Number of enforcement notices served under Article 30	Number of prohibition notices served under Article 31	Number of prosecutions for offences undr Article 32	Number of alterations notices served under Article 29	Number of premises satisfactory follwing enforcement action	Premises known to FRAs
	number of audits	of which satisfactory	of which unsatisfactory							
England	75,543	46,364	29,179	22,762	2,637	485	58	77	7,044	1,508,745

- overall attendance at incidents is down 40%;
- attendance at fires is down 48%;
- building fires, down 39%;
- minor outdoor fires, down 44%;
- road traffic collisions, down 24%;
- flooding, down 8%.

Over the longer term, the reduction in risk to the public from fire is even more dramatic. In 2011/12, 186 people died in accidental fires in the home. This is 60% lower than the average figure we saw annually in the 1980s. Firefighters themselves are also much safer today, even though they risk their lives to save the public.

Conclusions. The latter half of the last Century saw significant changes to the approach to dealing with fire in the UK. Technological solutions, especially affordable smoke detectors, legislative changes, including the control of foam furniture and the proactive approach to prevention have contributed to a fall in the number of fires and the number of fire deaths. The shift in responsibility from Government to the „sector" has prompted new partnerships, bringing together designers, constructors, building control bodies, equipment manufacturers, regulators and businesses to work together to manage the risk from fire. To be successful in continuing to improve effectiveness several conditions must be present. Performance systems require information to advise decisions. Competent people are needed to analyse information to make appropriate decisions, and the end user, the general public, need to have an informed voice representing them.

The Institution of Fire Engineers plays a significant part in this process. From its independent perspective its members drive innovation or make comment on ideas, drawing on its international Knowledge hub. The suite of examinations test learning and understanding across the World, having the effect of guiding students to relevant areas and giving those who must select competent persons to discharge critical duties, fire prevention, protection or emergency response, confidence in their ability. The Institution, a charity not aligned to Politics or commerce, with strong foundations stretching back nearly 100 years, is well placed to take a central role in this process, helping bring together the views of experts with the tensions of businesses, staving off the risk of complacency that the recent success in reducing risk could bring.

Neil Gibbins