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Comparative Simulation ResultsforEN-54, НПБ 88 and NFPA 72 Standards-the Hallway Case

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ABSTRACT

Fire detectors arrangement in object presents very important task in fire protection. This task was regulated by different standards. Standard references should be the same or similar, but for some detectors arrangement cases they are different. Particularly interested is the case of fire detectors arrangement in hallway.This paper has written to presents comparative simulation results of smoke detectors reactions in the case of hallway for three different burner`s positions and three different detector`s thresholds, according to EN-54, НПБ 88 and NFPA 72 standards.

Key words: detector, arrangement, simulation, standard

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I. INTRODUCTION

The fire detectors arrangement presents very responsible and serious task in the fire protection. Proper fire detectors arrangement is very important for forehand fire detection, especially for detection at early stage. This task was regulated by proper standards. It is known that several standards deal with these tasks: EN 54 (European norms), BS (British Standard), NFPA (National Fire Protection Association), НПБ 88-2001 (*Нормыпожарнойбезопасности*), VDE 088-2(*Verband der Elektrotechnik-originally-Association of German Electrical Engineers, now-Association for Electrical, Electronic & Information Technologies*) and other.

The general rule for needed number of fire detectors and its arrangement is to divide the supervised area with detector supervised area. In the case that this result doesn't provide whole number, the first bigger whole number should be taken. Of course, the influence of lots of other factors must be considered, such as wholes into the walls positions, shape and slope of the roof, walls positioning, barriers, girt installation positioning, room height, walls thickness and material (concrete, gypsum or some other materials), potential air currents, humidity, different nature disturbances etc. The locations of detectors must be easily accessible in case of its testing and repairing. Also, the distance of fire detectors from walls must not be less than 0.5 m except in case of narrows hallways-passes. The reduction of the range between detectors provides higher sensibility, but it doesn't mean that great fire detector`s number increment caused great system sensitivity. It is very important to find an optimal relation between needed detectors number and fire protection system sensitivity.As special cases for fire detectors arrangement, the cases with stairs, girts, galleries, slope roofs, duplicate roofs and hallways must be considered. For those cases also exist rules that must be respected. Hallways present very interesting cases because different standards have different interpretation about this topic [1-4].

The interpretation of EN 54 standard is next: "*Where rooms are divided into sections by walls, partitions or storage racks reaching to within 0,3 m of the ceiling, the dividers should be considered as if they reached the ceiling and the sections should be considered as separate rooms. A clear space of at least 0,5 m should be kept in all directions below each detector".* Obviously, this standard generally doesn't define the hallway concept and fire detectors arrangement in this case should be realized as for general cases (the distance in this case was 15 m) [5].

Standard НПБ 88 gives the recommendation only for smoke detectors. Related to this standard, the horizontal distance between detectors may be increased 1.5 times- as an example, for room height of 3.5 m maximal distance is 13.5 m [6].

One of the most detailed and most complex standards is NFPA 72 standard. The interpretation of this standard for hallway cases is next: "*A corridor 10 feet (3.0 m) wide and up to 82 feet (25.0 m) long can be covered with two 30 feet (9.1 m) spot type detectors. if a detector is assigned a coverage area of*

10 feet (3.1 m) by 41 feet (12.5 m), permitted under a 30 feet (9.1 m) spacing, and two such rectangular areas are stacked end-to-end, such as might be encountered in a corridor, there will be a distance of 42 feet (12.8 m) between adjacent detectors. The distance of 42 feet (12.8 m) between adjacent detectors in a corridor is consistent with the 30 feet (9.1 m) spacing for the detectors. For corridors of approximately 15 feet (4.6 m) in width and for fires of approximately 100 kW or greater, modelling has demonstrated that the performance of smoke detectors in corridors with beams has been shown to be comparable to spot smoke detector spacing on an unconfined smooth ceiling surface. In the narrowest of corridors, smoke detectors can be located as far apart as approximately 40 feet (12.2 m), regardless of the beams or joists at the ceiling"[7].

The aim of this paper was to show and compare simulation results for smoke detectors arrangement in the case of hallway, for EN-54, НПБ 88 and NFPA 72 standards.

II. SIMULATION MODEL

Simulation model for this paper was realized in PyroSim software, version 2012. There were several versions of this software in the last several years [8]. Simulation model used for this purpose implied object with dimensions 75 m x 30 m x 3.25 m. The object had five cross locations. Walls in the object were from concrete with thickness of 0.22 m. The width of every hallway was 3 m.

The fire source was modeled as burner with dimensions of 0.65 m x 0.65 m and HRR (Heat release rate per area) of burner were 10, 100, 500 and 1000 kW/m^2. The burner's positions were at the three different locations in the object. Smoke detectors were arranged according to the EN-54, НПБ 88 and NFPA 72 standards, with theirs thresholds of 1.6, 3.25 and 5.2 %/m. Simulation model of the object with its complete dimensions, burner`s position at the all three locations and smoke detectors arrangement according to the EN-54, НПБ 88 and NFPA 72 standards are presented on figures 1, 2 and 3[9], [10].

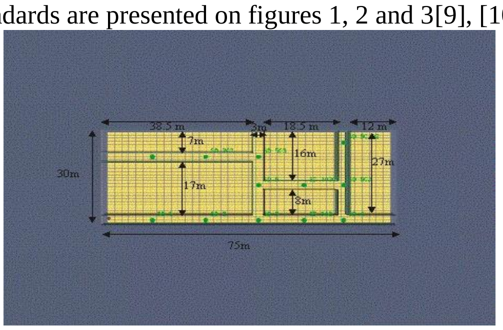

Fig. 1. *Simulation model of the object with its complete dimensions, burner`s position at the first location and smoke detectors arrangement according to the НПБ 88 standard*

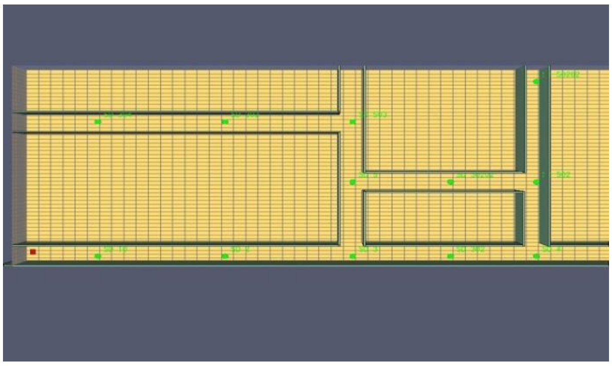

Fig. 2.*Simulation model of the object withburner`s position at the first location and smoke detectors arrangement according to the EN-54 standard*

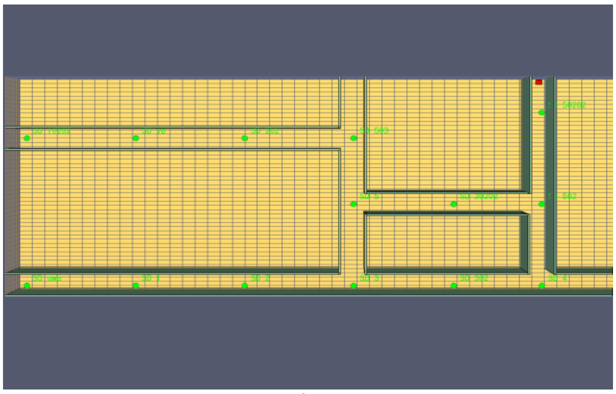

Fig. 3.*Simulation model of the object withburner`s position at the third location and smoke detectors arrangement according to the NFPA 72 standard*

III. SIMULATION RESULTS

The machine used for simulations was laptop Lenovo IdeaPad G50-80 80E502F3YA, with Intel Core i5-5200U processor (2 cores, 2.20GHz, 3MB cache), DDR3L memory controller (up to 1600MHz), Intel Turbo Boost 2.0 (2.70GHz) and 8GB of DDR3 RAM.It is a recommendation to use strong hardware and software configuration for simulations with demanding numerical and graphical calculations. The simulation time was set on 300 seconds for each simulation. Some of simulation moments for every three positions of the burner and some of burner`s HRR are presented on figures from 4 to 22, while the complete simulation results for all three thresholds of burners (1.6, 3.25 and 5.2 %/m) are presented on figures23, 24 and 25.

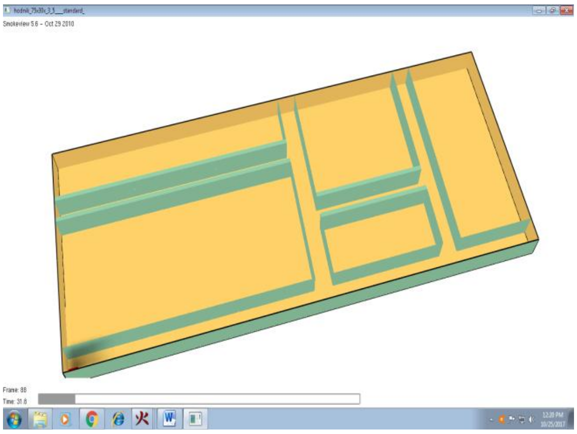

Fig. 4.*Simulation moment after 31.8 seconds for the first burner`s location and burner`s HRR of 10 kW/m²*

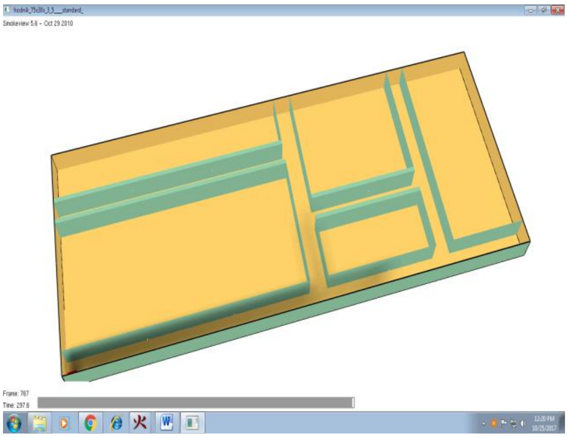

Fig. 5.*Simulation moment after 297.6 seconds for the first burner`s location and burner`s HRR of 10 kW/m²*

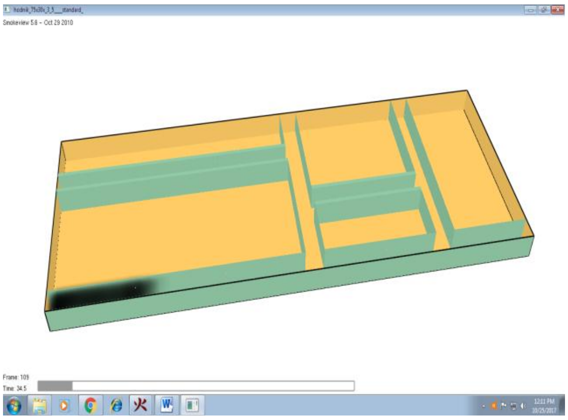

Fig. 6.*Simulation moment after 34.5 seconds for the first burner`s location and burner`s HRR of 100 kW/m²*

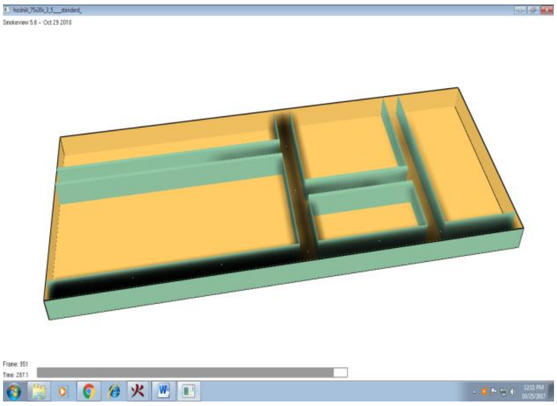

Fig. 7.*Simulation moment after 287.1 seconds for the first burner`s location and burner`s HRR of 100 kW/m²*

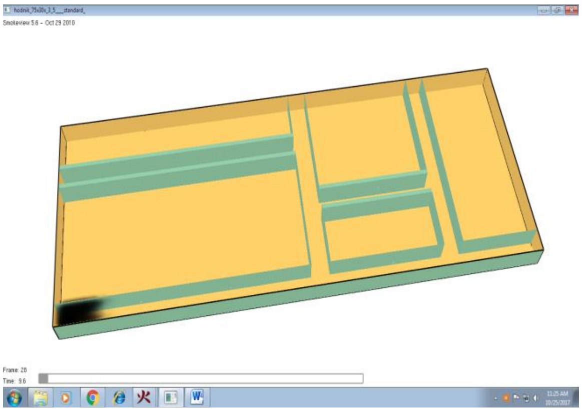

Fig. 8.*Simulation moment after 9.6 seconds for the first burner`s location and burner`s HRR of 500 kW/m²*

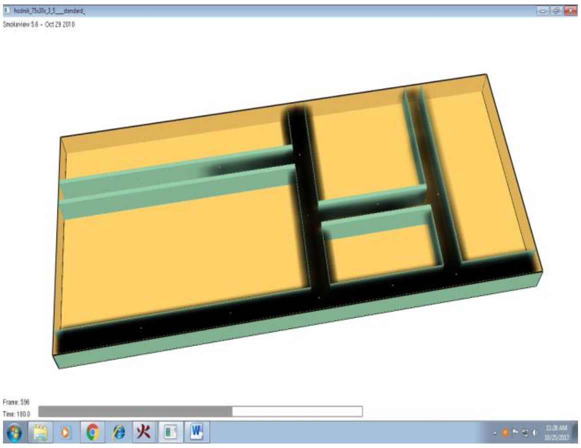

Fig. 9.*Simulation moment after 180 seconds for the first burner`s location and burner`s HRR of 500 kW/m²*

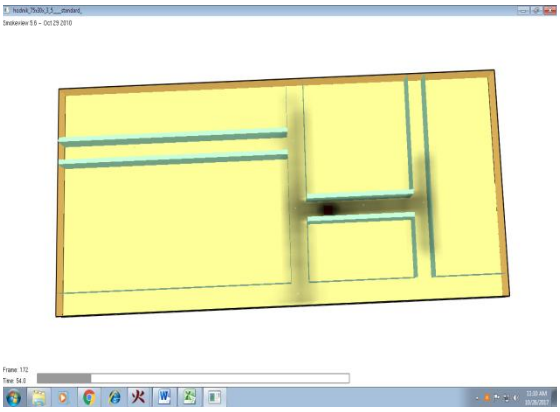

Fig. 10.*Simulation moment after 54.0 seconds for the second burner`s location and burner`s HRR of 100 kW/m*^{2}

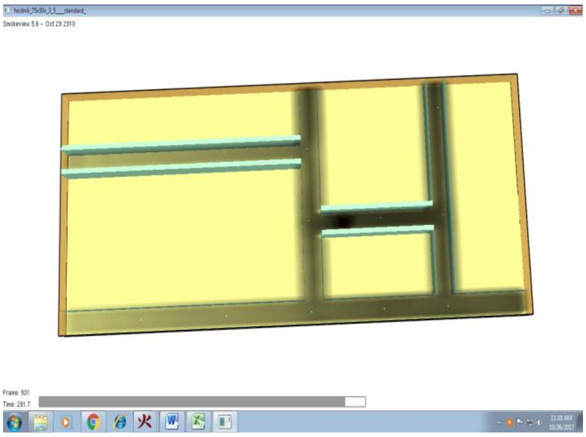

Fig. 11.*Simulation moment after 281.7 seconds for the second burner`s location and burner`s HRR of 100 kW/m*^{2}

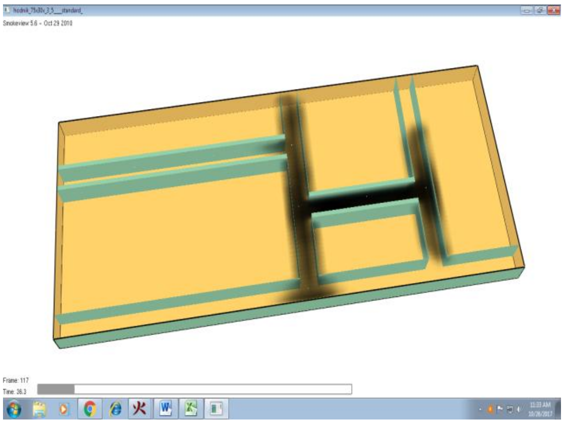

Fig. 12.*Simulation moment after 36.3 seconds for the second burner`s location and burner`s HRR of 500 kW/m*^{2}

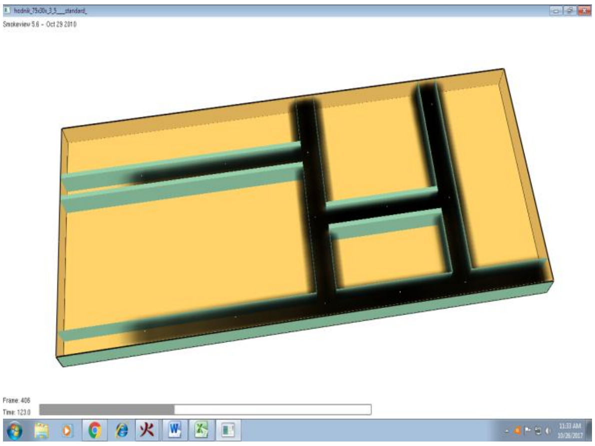

Fig. 13.*Simulation moment after 123.0 seconds for the second burner`s location and burner`s HRR of 500 kW/m*^{2}

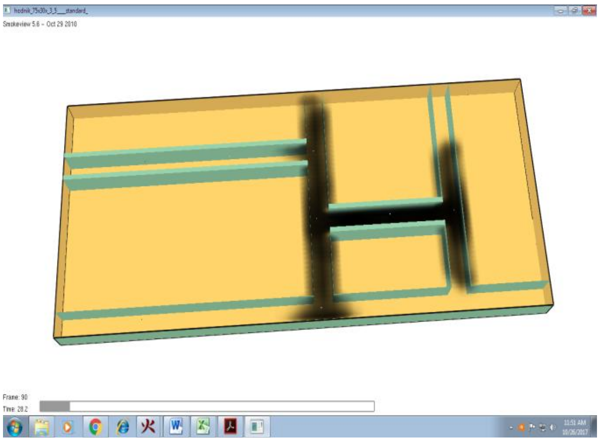

Fig. 14.*Simulation moment after 28.2 seconds for the second burner`s location and burner`s HRR of 1000 kW/m*^{2}

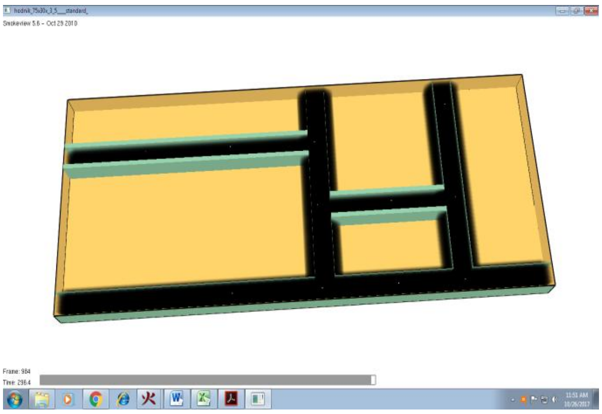

Fig. 15.*Simulation moment after 296.4 seconds for the second burner`s location and burner`s HRR of 1000 kW/m*^{2}

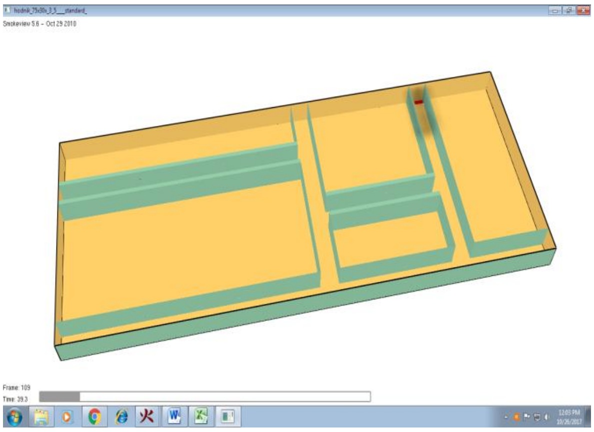

Fig. 16.*Simulation moment after 39.3 seconds for the third burner`s location and burner`s HRR of 10 kW/m*^{2}

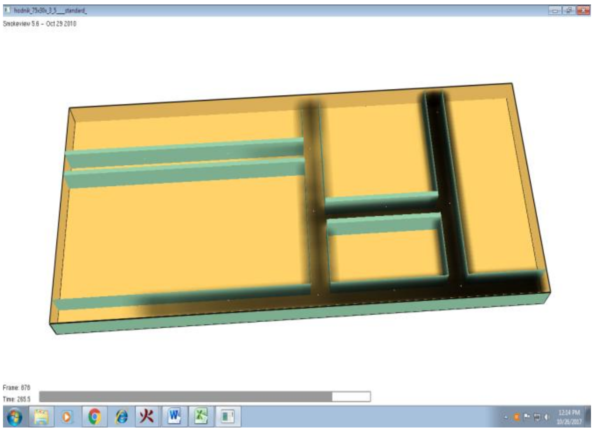

Fig. 19.*Simulation moment after 265.5 seconds for the third burner`s location and burner`s HRR of 100 kW/m*^{2}

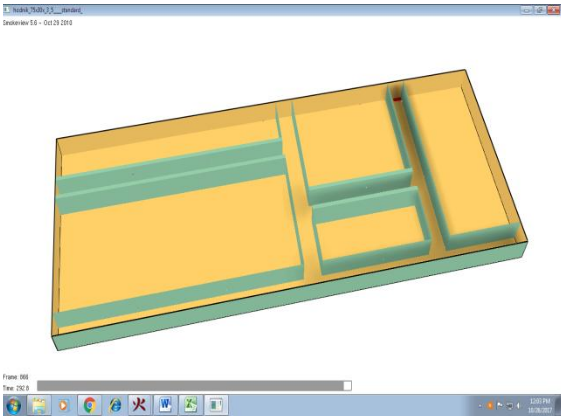

Fig. 17.*Simulation moment after 292.8 seconds for the third burner`s location and burner`s HRR of 10 kW/m*^{2}

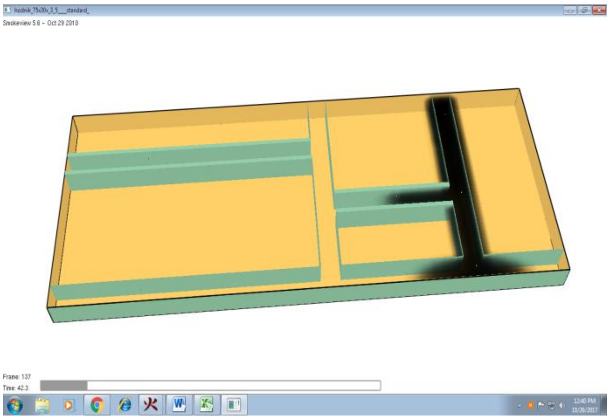

Fig. 20.*Simulation moment after 42.3 seconds for the third burner`s location and burner`s HRR of 500 kW/m*^{2}

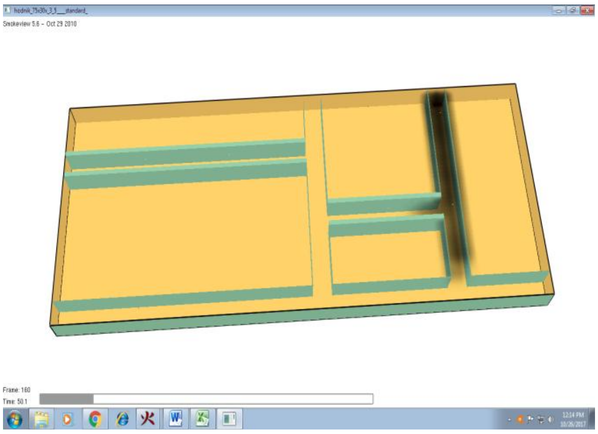

Fig. 18.*Simulation moment after 50.1 seconds for the third burner`s location and burner`s HRR of 100 kW/m*^{2}

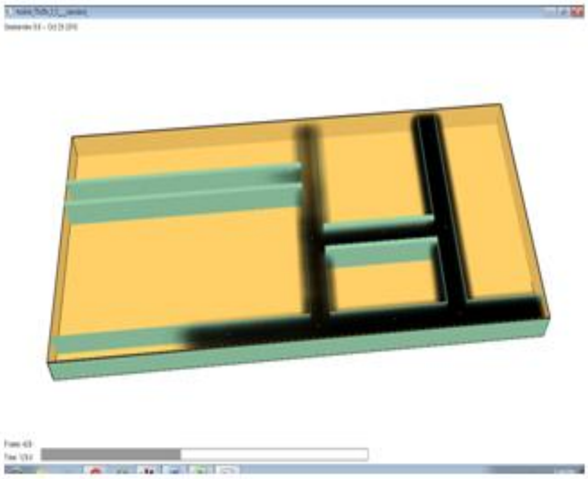

Fig. 21. *Simulation moment after 129.0 seconds for the third burner`s location and burner`s HRR of 500 kW/m²*

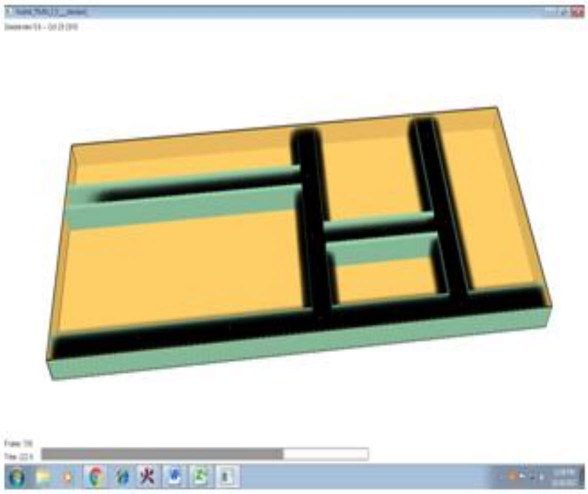

Fig. 22. *Simulation moment after 222.9 seconds for the third burner`s location and burner`s HRR of 1000 kW/m²*

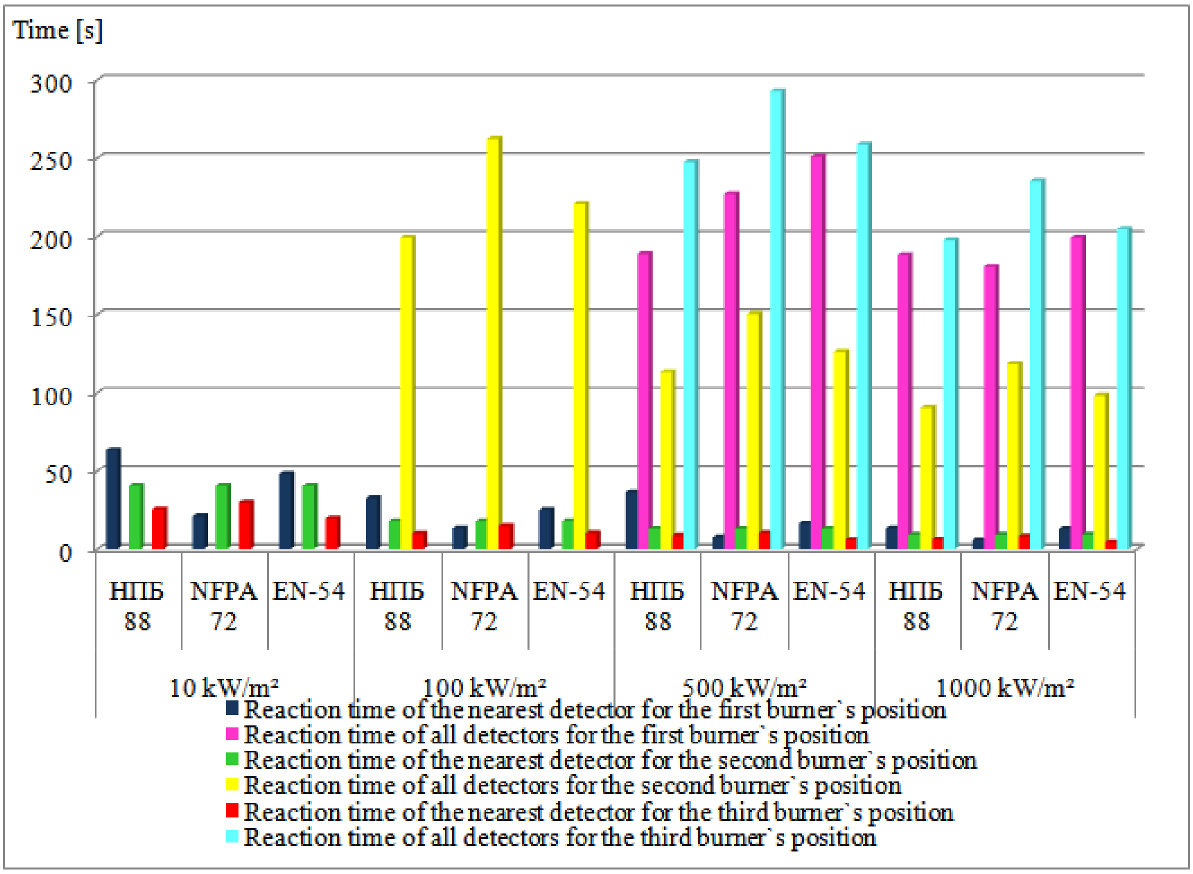

Fig. 23. *The complete simulation results for both standards, for every of three burner`s positions and for every of burner`s HRR (5, 25 and 50 kW/m²) and smoke detectors threshold of 1.6 %/m*

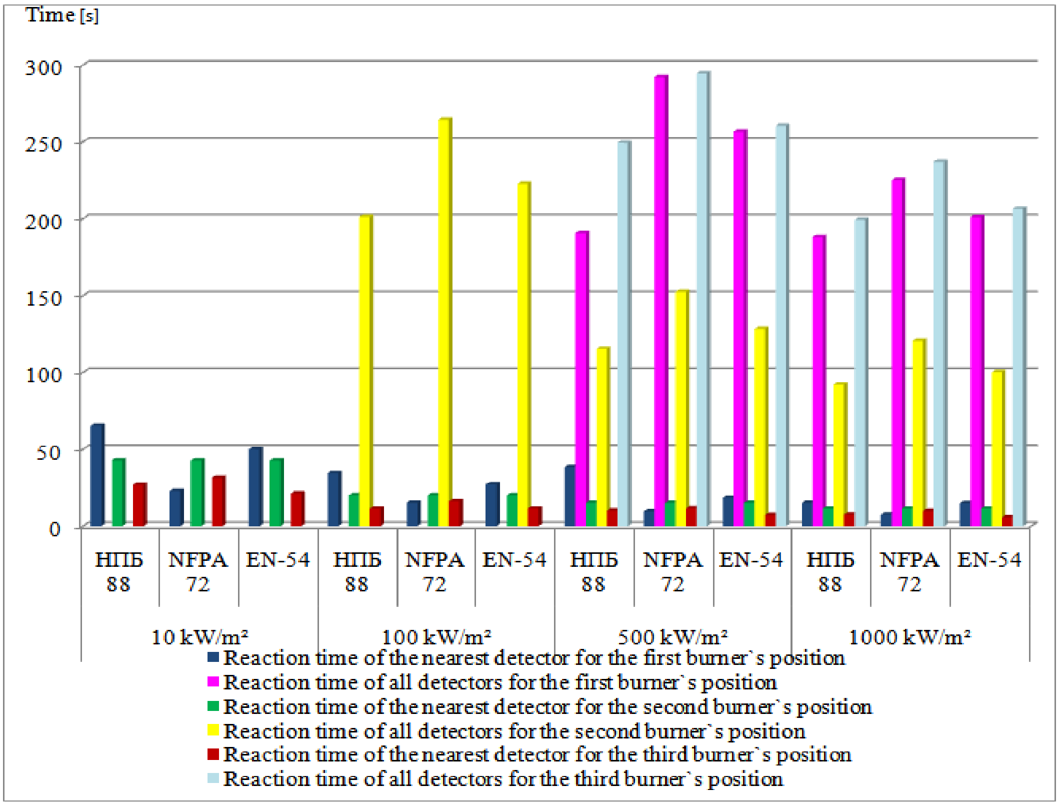

Fig. 24.*The complete simulation results for both standards, for every of three burner`s positions and for every of burner`s HRR (5, 25 and 50 kW/m^2) and smoke detectors threshold of 3.25 %/m*

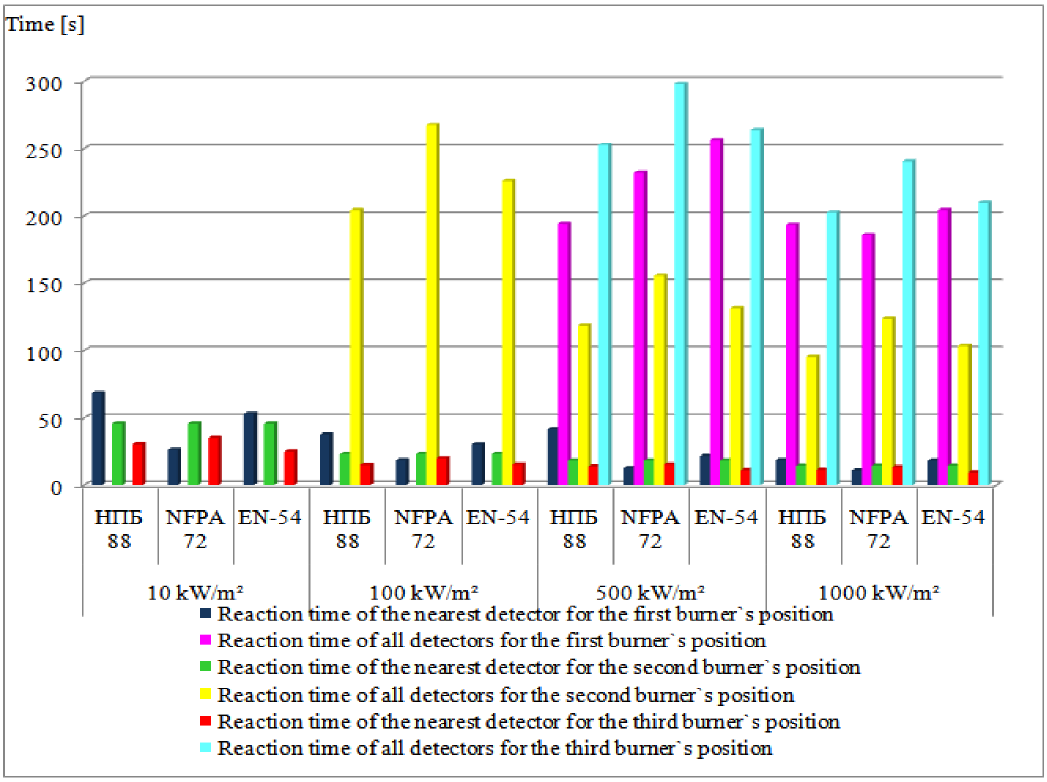

Fig. 25.*The complete simulation results for both standards, for every of three burner`s positions and for every of burner`s HRR (5, 25 and 50 kW/m^2) and smoke detectors threshold of 5.2 %/m*

IV.ANALYSE OF RESULTS

At the first place, it is important to note that realized and expected results for all of three thresholds of alarms were confirmed. The greater sensitivity of detectors implied shorter reaction time. The differences between reaction times were small, but they were exist (for example, for the first burner`s position for all of three thresholds and HRR of burner of 10 kW/m^2, reaction times were 63.43, 65.84 and 68.53 in the case of НПБ 88 standard).

Realized results for the first burner`s position showed that reaction time of the nearest burner, for all of four HRR of burner was longer for НПБ 88and EN-54 standards related to NFPA 72 standard (figures 23, 24 and 25). According to the fact that activation thresholds for smoke detectors were1.6, 3.28 and 5.2 %/m of obscuration, reaction time of all detectors for the first burner`s position was bigger than maximum simulation set time of 600 seconds for 10 and 100 kW/m^{2}for every three positions of burner.

Realized results for the second burner`s position for all of four HRR of burner in the case of reaction time of the nearest detector were the same. But, in the case of the reaction times of all detectors, reaction time of all detectors related to НПБ 88and EN-54 standards were shorter than reaction time of all detectors related to NFPA 72 standard (figures 23, 24 and 25- for burner`s HRR of 100, 500 and 1000kW/m$^2$ . For burner`s HRR of 10 kW/m^2 the reaction times of all detectors was longer than maximum simulation time of 600 seconds.

Realized results for the third burner`s position showed that reaction time of the nearest burner, for all of four HRR of burner was slightly longer for NFPA 72 standard than for НПБ 88and EN-54 standards(figures 23, 24 and 25). Reaction times for all detectors, for HRR of burner of 500 and 1000 kW/m^2 were also slightly longer for NFPA 72 standard than for НПБ 88and EN-54 (for example, for burner`s HRR of 1000 kw/m^2 reaction time for all detectors for NFPA 72 standard was 240.54 seconds while the reaction times for НПБ 88and EN-54 standards were 202.71 seconds and 209.89 seconds).

V. CONCLUSION

The fire detectors arrangement in the hallways cases is different related to different standards and the main difference is in the fire detectors number and their between distance. In the results realized in this paper, the complete number of smoke detectors in thecase of НПБ 88and EN -54 standards were 12 while their completenumberin the case of NFPA 72 standard was 14.This cause that reaction times of the nearest detectors were shorter for detectors arranged according to NFPA 72 standard than detectors arranged according to НПБ 88and EN-54 standards. On the other hand, complete times of all detectors were longer than 300 seconds except for the second burner`s position, where the complete time of all detectors were longer according to NFPA 72 standard than НПБ 88and EN-54 standards, because of greater detectors number and their less between distances in the case of NFPA 72 standard.

Realized simulations again showed that no matter on used standard, detectors arrangement can be different from case to case, especially in the cases that were noted as special cases (hallways, stairs, ceiling, objects with no standard geometry and similar). Greater number of fire detectors does not cause huge benefit in safety so, according to all noted, it is very important to find an optimal relationship between detectors number and their arrangement in particular object. This paper can present a good start base for some future investigations, such as smoke detectors arrangement in special cases according to valid standards (stairs, double-perforated ceilings, slope roofs, rooms and objects with no standard geometry),fire and smoke spreading and behaviour in areas with specific geometry and from different materials etc[11-14], [2].

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