The Smoke Detectors Arrangement in Rooms With Girts Related to British Standard BS 5839-1

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1. INTRODUCTION

Fire detectors present devices with purpose to detect the fire at early stage. Their importance in fire protection is huge, better to write crucial. Fire detectors can be divided differently, mostly related to the fire product (smoke, heat, flame, CO etc.) The most used group of fire detectors present smoke detectors. Their construction was based on two different principles: radioactive principal and optical principal. Their sensitivity depends from smoke particles dimensions. Related to that fact, ionization smoke detectors are more convenient for smokes with smaller „invisible“ particles, while optical smoke detectors are more convenient for smokes with bigger particles.

The arrangement of smoke detectors is strictly defined by rules and standards. The most famous standards are EN 54 standard (European norms), BS standard (British Standard), NFPA standard (National Fire Protection Association), VDE 088-2 standard (Verband der Elektrotechnik-originally-Association of German Electrical Engineers, now-Association for Electrical, Electronic & Information Technologies), НПБ 88-2001 standard (Нормы пожарной безопасности) and others. There are many similar but also many different items in standards related to arrangement of smoke detectors. Generally, the needed number of fire detectors in one room is defined as a quotient between room’s surface and covering surface range of one detector. Also, performances of fire detectors (particularly smoke and heat detectors) depend from distance between detector and ceiling above detector (point fire detectors). Besides general cases, there are many special cases for fire detectors arrangement where general rules must be modified. For those cases, there are also similarities and differences between different standards.

This paper was written to show the smoke detectors arrangement in case with room with parallel girts related to BS standard (British standard 5839-1) and simulation check of potential cases in FDS software [2].

2. INSTALLATION OF SMOKE DETECTORS IN ROOMS WITH OBSTACLES

One of special cases in smoke and, generally fire detectors arrangement is the installation of fire detectors in rooms with different obstacles, such as girts, partitions, stocked goods and similar. Of course, this special case was regulated with different standards. One of these standards is British standard BS 5839-1.
Related to this standard, obstacles in room that can achieve height of 300 mm divide the complete space to special wholes. At the same principle, girts with its depth bigger than 10 % from room’s height should be treated as walls. The part 6 of this standard specifies that if in some case installation of fire detectors on ceiling is not possible, then fire detectors can be installed on the wall. It is important to note that in that case, next rules must be applied:

- the top of the detector must be between 150 mm and 300 mm below the ceiling;
- the bottom of the detector must be above the any doors level and
- the manufacturer of the detector must predict the installation of the detector on the wall.

This also applies for rooms which surface is no bigger than 50 m² but with one dimension up to 10 m.

The installation of fire detectors in case with girts and stacked goods inside the room is presented on figure 1. It is also important to note that dimension marked as H* on figure 1 presents distance of girt from the ceiling and in case that this dimension is bigger than 10% of the height of the room, then that space must be considered as separate room.

In the case when the ceilings are in the form of honeycomb with series of smaller cells, the fire detectors can be installed direct on the girt or in the space between girts, as it is presented on figure 2. Dimension on figure 2 marked as H presents the height of the room, dimensions marked as L presents the distance between girts and the dimension marked as L presents the depth of the girt. The rules for installation of fire detectors in this case, related to BS 5839-1 standard are presented to table 1.

![Figure 1 - Point fire detectors installation in case when the girts and stocked goods are present in the room](image1)

![Figure 2 - Point fire detectors installation in case when the ceiling is in the form of „honeycomb”](image2)

Table 1. The rules for installation of fire detectors in the case when the ceiling is in the form of honeycomb related to BS 5839-1 (table source: Blagojević, M, Fire protection systems designing, pp. 176)

<table>
<thead>
<tr>
<th>Case</th>
<th>The height of the room H [m]</th>
<th>The depth of the girt D</th>
<th>Maximal distance of any point from the fire detector [m]</th>
<th>Fire detector’s position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smoke detectors</td>
<td>Fire detectors</td>
</tr>
<tr>
<td>1</td>
<td>H ≤ 6 m</td>
<td>less than 10% H</td>
<td>The same as for the plane ceiling</td>
<td>The same as for the plane ceiling</td>
</tr>
<tr>
<td>2</td>
<td>H &gt; 6 m</td>
<td>less than 10% H and 600 mm or less</td>
<td>The same as for the plane ceiling</td>
<td>The same as for the plane ceiling</td>
</tr>
<tr>
<td>3</td>
<td>H &gt; 6 m</td>
<td>less than 10% H and more than 600 mm</td>
<td>The same as for the plane ceiling</td>
<td>The same as for the plane ceiling</td>
</tr>
<tr>
<td>4</td>
<td>H ≤ 3 m</td>
<td>more than 10% H</td>
<td>4.5 m</td>
<td>3 m</td>
</tr>
<tr>
<td>5</td>
<td>H = 4 m</td>
<td>more than 10% H</td>
<td>5.5 m</td>
<td>4 m</td>
</tr>
<tr>
<td>6</td>
<td>H = 5 m</td>
<td>more than 10% H</td>
<td>6 m</td>
<td>4.5 m</td>
</tr>
<tr>
<td>7</td>
<td>H ≥ 6 m</td>
<td>more than 10% H</td>
<td>6.5 m</td>
<td>5 m</td>
</tr>
</tbody>
</table>

In the case when ceiling purports more parallel girts, point fire detectors distance is increased related to rules presented in table 2, as it is presented on figure 3 [1].
Table 2. Maximal distance between point fire detectors in the room with parallel girts related to BS 5839-1 (table source: Blagojević, M, Fire protection systems designing, pp. 177)

<table>
<thead>
<tr>
<th>Case</th>
<th>Room`s height [m]</th>
<th>The depth of the girt</th>
<th>Maximal range between detectors M [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smoke detectors [m]</td>
</tr>
<tr>
<td>1</td>
<td>H ≤ 6</td>
<td>less than 10% H</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>H &gt; 6</td>
<td>less than 10% H and 600 mm or less</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>H &gt; 6</td>
<td>less than 10% H and more than 600 mm</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>H ≤ 3</td>
<td>more than 10% H</td>
<td>2.3</td>
</tr>
<tr>
<td>5</td>
<td>H = 4</td>
<td>more than 10% H</td>
<td>2.8</td>
</tr>
<tr>
<td>6</td>
<td>H = 5</td>
<td>more than 10% H</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>H ≥ 6</td>
<td>more than 10% H</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Figure 3 - Point fire detectors installation between parallel girts

3. SIMULATION MODEL

Simulation model for the purposes of this paper was realized in FDS (fire dynamics simulator) software, version 6.6. This software presents very important engineering tool in fire and smoke prediction and calculation. Special benefit of this software is a potential to visual present numerical results. Simulation model for this paper was a room with girts-obstacles with dimension 30 m x 20 m. The height of the room was from case to case, related to table 2: the first case H=5.5 m, the second and the third case H=6.5 m, the fourth case H=3 m, the fifth case H=4 m, the sixth case H=5 m and the seventh case H=6 m.

The depth of the girts were from case to case, also related to table 1: the first case D=0.4 m, the second and the third case D=0.6 m, the fourth case D=0.5 m, the fifth case D=0.75 m, the sixth case D=0.75 m and the seventh case D=0.75 m.

There were three different positions for burners as fire and smoke sources. The first burner position was at the beginning of the room; the second burner position was at the middle of the room`s side, while the third burner position was at the middle of the room.

For all three burner positions, simulations were realized for three different values of HRR (Heat release rate per area): 500 kW/m², 1500 kW/m² and 4500 kW/m².

The simulation model with marked burner`s positions are presented on figure 4., while the simulation model for the first case with third burner position and smoke detectors arrangement presented on figure 5 [3].

Figure 4 - Simulation model in FDS of the room with girts and all three marked burner locations

Figure 5 - The simulation model in FDS for the first case with third burner position and smoke detectors arrangement
4. SIMULATION RESULTS

The computer used for simulations in this paper was laptop DELL G15 5511, 15.6" FHD 120Hz, High-brightness 250-nits, processor model i7-11800H, 16-GB RAM, 512GB SSD, GeForce RTX.

It is always recommended to use computer with strong hardware for this kind of calculations and simulations. The average simulation duration time was 426 seconds.

The limitations of this paper allowed that only some results for some cases are presented on figures from 6 to 9, while the complete results for every case, for every burner’s position and every burner’s HRR are presented on figure 10.

Figure 6 - Thermal presentation of simulation results for the second case with the first burner position and burner’s HRR of 500 kW/m²

Figure 7 - Simulation results for the first case with the third burner position and burner’s HRR of 1500 kW/m²

Figure 8 - An example of graphic presentation of results for the nearest smoke detector from the burner for the second case with third burner’s position and burner’s HRR of 4500 kW/m²

Figure 9 - An example of graphic presentation of results for the farthest smoke detector from the burner for the fourth case with third burner’s position and burner’s HRR of 1500 kW/m²

Figure 10 - The complete simulation results for every simulated case for all three burners’ positions and all three burners HRR (500 kW/m², 1500 kW/m² and 4500 kW/m²)
On figure 10, where the complete simulation results are presented, mark NSD presents the nearest smoke detector, mark FSD presents the farthest smoke detector, while marks B1, B2 and B3 present burner’s HRR (B1- 500 kW/m², B2- 1500 kW/m² and B3- 4500 kW/m²).

5. RESULTS ANALYSE

Realised simulation results presented all potential cases for room with girts, related to British standard 5839-1 and presented in table 2. The results for the nearest smoke detectors to the fire source (burner) was expected and the difference between them is in few seconds, related to the time needed for the smoke detector’s reaction, what was negligible. There were some differences for the results for the farthest smoke detectors. The longest time required for the farthest smoke detector reaction was for the fourth case, for the first burner position, with HRR of burner from 500 kW/m², and it was 97.15 seconds. The shortest time required for the farthest smoke detector reaction was for the first case, for the second burner position, with HRR of burner from 4.500 kW/m², and it was 23.6 seconds. The reason for these differences lies in the fact that the depths of the girt were not the same for every case (related to simulations conditions and demands, the depths of the girts were from 0.4 to 0.75, in dependence of case). Of course, the important reason was burner’s HRR. It was logic that bigger HRR would have the shorter time needed for reaction (for this paper, burner presented fuel with huge quantities of heat and smoke in case of burning). However, the presence of girts in room must be carefully analysed and taken into account.

6. CONCLUSION

Correct installation of smoke detectors has the crucial importance in early fire detection and avoiding of the hardest consequences. The use of simulation software in testing of smoke detectors arrangement related to determine rules or standards present very important, modern, safe and cheap way for identification and verification of rules for detectors recommended by standards. Great number of different cases with different conditions can be solved very fast and very effective [4-6]. Simulation software must present mandatory tool for every engineer, especially for designer engineer.

REFERENCES


REZIME

RASPORED DETEKTORA DIMA U PROSTORIJAMA SA GREDAMA PREMA BRITANSKOM STANDARDU BS 5839-1


Ključne reči: dim, detektor, simulacija, greda, BS 5839-1