Simulation of fire development in a large-area shopping hall

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Abstract. The results obtained after numerical simulation of fire development in a large area shopping hall are presented and widely discussed. The analysis has been conducted for two types of halls differing in size and efficient ventilation capabilities. A fire development scenario has been forecast under the assumption that a sufficient number of smoke vents had been installed as required by the provisions of law. The obtained results have been related to the hypothetical case where there were no smoke vents whatsoever. The stacking height of the merchandise gathered in the hall has been differentiated during the analysis as well. The numerical simulations have been performed with application of the FDS computer program. It has been assumed, that the fire had been initiated by a single source uniquely defined and initially limited in spatial area of influence. The results obtained indicate that the spatial and temporal fire development is different for each of the considered scenarios. The key role of the possible limitations in the exchange of gases between the area affected by fire and the environment, influencing the way and speed with which the fire propagates, has been confirmed during analysis.

1. Introduction
In the general design practice, when an authoritative response of a complex bearing structure to the external actions including fire exposure is sought, commonly a fully developed fire scenario is considered, with fire plume gas temperature increasing in time but distributed evenly within the affected fire compartment. An assumption of this type, especially pertaining to the building structures of large area and large enclosed volume seems to constitute an unnecessary oversimplification with currently available computational models. In such cases fire load gathered in the fire zone, at the ventilation conditions existing in reality, only rarely is capable of generating a fire having sufficient combustion energy to, even if only locally, reach the stage of fully developed fire. Thus an assumption of a localized fire, characterized by the fire plume temperature varying in space and time, seems to be far more rational from both technical and economic point of view. Forecasting the potential fire development within the considered fire compartment, under the assumed initial conditions and unequivocally defined, in general known a’priori, boundary conditions thus becomes one of basic tasks facing the expert evaluating the safety level ensured to the user of the considered structure. Only following such, undoubtedly non trivial analysis, one may on the one hand verify the real level of risk, however refraining from overestimating it, as usually happened when the fully developed fire model has been applied, and subsequently, on the other hand determine the locally changing temperature field affecting, as the exceptional load accompanying other loads, the considered bearing structure.

2. Description of the halls and fire scenarios analyzed in detail in this paper
The considerations presented in this paper pertain to the fire development forecast in large area shopping halls. The specificity of fire compartments of this type lies in the fact, that at very large surface area they have relatively low height. In addition, due to the way of use, these halls are densely filled with storage racks, on which the merchandise is stockpiled. The merchandise, and in many cases the rack structure itself [1], constitute a potential fuel after the fire initiation, interpreted in the following analysis as an important component of the total fire load in the considered hall. The storage racks, filled with densely packed and often combustible merchandise, in themselves may constitute a...
potential fire source, bursting into flames in a sequence with fire plume temperature increasing in their direct vicinity. In addition, these racks obstruct the efficient ventilation of the hall. The ventilation, in the case of fire, is to assure the exchange of exhaust gasses with the surroundings. This on one side allows for more or less restricted delivery of combustion supporting oxygen [2], but on the other side is necessary to create at least temporarily the conditions for safe evacuation. In order to completely describe the restrictions affecting the ventilation of so characterized fire compartment one has to add that in most cases compartments of this type are completely devoid of windows and number and size of access gates is relatively small as well. Thus proper formation of such fire compartments, allowing for instance for gravitational evacuation of smoke gathering under the ceiling, is commonly required by the building codes. An application of smoke vents to evacuate the smoke to the outside may be required by the code as well.

Let us consider here two types of shopping halls, the first of which represents a hall of rather average usable area, while the second one represents a typical large area shopping hall [3, 4]. The in plan dimensions of the smaller hall are 52.00m by 36.00m, with constant height equal 4.50m (Figures 1 and 2). The same dimensions of the large shopping hall are 135.00m by 60.00m with a height of 7.00m (Figure 3). As one can see, in both of these halls the roof was modelled as a flat one, because in a real object the slope angle was only about 5%. Furthermore, in both cases the numerical models assumed the existence of permanently open access gates. It was assumed, that in the smaller hall one large gate having the dimensions of 3.50m by 3.00m is located in the front, shorter wall, while two smaller gates having the dimensions of 1.00m by 2.50m are located in the side wall (Figures 1 and 2). Locations and dimensions of the access gates in the large hall are analogous to those assumed for the smaller hall. The only difference is in the fact, that instead of two, three small access gates are present in the side wall (Figure 3). The sheathing is modeled as typical, made of sandwich panels with 15cm thick mineral wool core. The properties of the insulating material, dependent on the temperature affecting it, have been assumed according to [5]. It has been also assumed, that before the initiation of fire the internal temperature of the hall was constant and equal to 20°C. It has been assumed as well, that regularly spaced storage racks in the halls contain the stockpiled merchandise (a derivative of cellulose, i.e. mostly paper like materials). These represent the basic fire load in the fire compartment. In addition 3x5=15 evenly spaced smoke vents having the dimensions of 2.00m by 2.50m each (Figures 1-2) have been located in the roof over the smaller hall. These smoke vents are opened individually after the activation of the temperature sensor, with the activation temperature set to 74°C. Analogous vents, of the same type and size have been assumed to be installed in the roof over the large hall. Of course the number of the vents over the large hall has been much higher than before and was equal to 6x13=78 (Figure 3). For comparative reasons, the fire development scenario in both halls devoid of smoke vents has been considered as well.

Figure 1. General view of the small shopping hall considered in the scenario A. The locations of the open gates and smoke vents are indicated.

Figure 2. Distribution of the storage racks with paper like merchandise in the small hall considered in the scenario A. The location of fire source initiating the fire and the authoritative cross section depicting the distribution of fire plume temperature in the selected moment of fire exposure are indicated.
In the first two fire development scenarios simulated by the authors, of which the first one (scenario A) pertained to the smaller hall, while the second one (scenario B) pertained to the large one, the same stacking height of 3.50m has been assumed. This meant, that in the case of large hall and scenario B much more unobstructed space remained between the ceiling and the rack tops, than in the case of small hall and the scenario A (i.e. 3.50m and 1.00m respectively). In order to at least partially overcome the quantitative influence of this difference an additional scenario C has been considered (an alternative to the scenario B), where the stacking height has been increased from 3.50m to 5.50m while leaving other parameters of the scenario B unaffected. This means, that in the scenario C only 1.50m of the free space remained between the rack tops and the ceiling.

**Figure 3.** Distribution of the storage racks with paper like merchandise in the large hall considered in the scenario B, with low stacking height. The location of fire source initiating the fire and the authoritative cross section depicting the distribution of fire plume temperature in the selected moment of fire exposure are indicated.

**Figure 4.** Scenario A – Fire plume temperature map obtained in the authoritative cross section of the smaller hall after 10 minutes of fire exposure, under the assumption that the smoke vents have been activated sequentially when the temperature in their nearest vicinity reached 74°C. The isotherm depicted in black delimits the zone inside of which the temperature exceeded 100°C. Open smoke vents are visible.

**Figure 5.** Scenario B – Fire plume temperature map analogous to the map depicted in figure 4, determined at the same cross section of the considered hall after 10 minutes of fire exposure, under the assumption that there are no smoke vents. The interpretation of the isotherm depicted in black is the same as in the previous figure.
The numerical simulation of fire development in the considered halls has been performed with application of Fire Dynamic Simulator (FDS) [6]. Convection, radiation and heat penetration through the partitions have been taken into account. A flame modeled as localized fire exhibiting the heat generation intensity of 500kW/m² and total power of 25MW (recommended in [7] as the maximum for the steel structures and stockpiling of combustible materials) initiated the fire. The duration of this initial fire has been set to 120 seconds, and its location is indicated in Figures 2 and 3. The fire initiated in this manner developed further, in the scenario A engulfing, while in the scenario B not engulfing additional racks in the hall. The intensity of fire development has been conditioned by the fire compartment geometry, the fire load gathered in the fire compartment and the available ventilation. The materials stockpiled on the racks have been modeled by the following physical properties: specific heat 1.36J/(kg⋅K), heat conductivity 0.25W/(m⋅K), volumetric weight 1100kg/m³. The flash point has been set to 250°C, and he chemical composition has been modeled in a simplified manner, as for cellulose, based on [5].

3. Development of the fire plume temperature during each of the considered fire scenarios

3.1. Scenario A
Detailed results of the fire plume temperature development, obtained for the fire forecast in the scenario A for the smaller of considered halls, are depicted in Figures 4, 5, 6 and 7. The location of source flame initiating the fire development is indicated in Figure 2. This location determines the location of the authoritative cross section, for which the fire plume temperature map is determined during the fire exposure. Let us consider the fire plume temperature map depicted in Figure 4 and obtained after 10 minutes of fire, in the hall equipped with operating smoke vents, as the reference one. The isotherm depicted in black in this picture refers to the temperature of 100°C. Thus the temperature in the zone surrounded by this isotherm is higher than 100°C, while the temperature outside of this zone is lower. Let us note, that this isotherm in this case is located relatively high above the floor level, and thus the zone containing relatively cool air after this long time of fire exposure is sufficiently thick to allow for safe evacuation. The limited thickness of fire plume under the roof is obviously the result of operating smoke vents evacuating hot combustion gases outside, as may be observed in Figure 4. Comparison of this picture with Figure 5, in which the analogous distribution of temperature determined in the same cross section of the hall and after the same fire exposure time is depicted, but this time for the hall in which the smoke vents did not activate, shows how much faster would the potential fire develop in a hall of the same fire compartment geometry and the same distribution of access gates ventilating the compartment, should one forego the additional obligatory equipment. As it is indicated in Figure 5, after 10 minutes of fire exposure the user of fire compartment stands no chance of evacuation. The temperature of fire plume in the whole height of the considered cross section, i.e. in its layer next to the floor as well, reaches now the level of 100°C.

A comparison of fire plume temperature maps obtained in the smaller hall in the horizontal cross section at the height of 4.00m above the floor level after 10, 15 and 20 minutes of fire exposure (Figure 6) may yield interesting conclusions. One may easily notice, that only after 20 minutes of the fire forecast for this hall the fire reaches the symptoms of fully developed one in large part of the considered fire compartment. In general all materials gathered in this area are on fire, and the temperature of the fire plume tends to equalize. This development is rather of local nature, as it does not affect the whole area of the considered hall. The graph depicting fire plume temperature in the authoritative cross section of the considered hall shown in Figure 2, at the height of 4.00m above floor level, seems to support this conclusion. The levels of temperature depicted in Figure 7, however, have been reached much later, after one hour of fire exposure. The results of simulations conducted for a hall equipped with operating smoke vents and the hypothetical one devoid of such vents are juxtaposed and compared here [8, 9].
Figure 6. Scenario A – Fire plume temperature maps obtained in the horizontal cross section of the analyzed small hall at the height of 4.00m above the floor level, under the assumption, that the smoke vents operate as indicated above, after: a) 10 minutes, b) 15 minutes, c) 20 minutes of fire exposure, respectively. In this case the isotherm depicted in black delimits the zone inside of which the temperature exceeded 350°C. The location of the source of flame initiating the fire is indicated by the darkened square.

Figure 7. Scenario A – Graphs of fire plume temperature obtained after one hour of fire exposure in the authoritative cross section of the smaller hall (depicted in figure 2), at the height of 4.00m above the floor level. The top graph refers to the hall equipped with operating smoke vents, while the bottom one to analogous hall devoid of vents.
3.2. Scenario B

The scenario A pertaining to the fire development simulation for the smaller of the considered halls is not typical for halls of the same type but having larger area. If the fire zone is sufficiently large (and this refers not only to the area, but also to the volume of the hall) the probability of fire progressing to the stage of fully developed one is negligibly small. For such a development to occur the availability of combustible materials, characterized by the sufficiently high burning efficiency, distributed evenly over the whole fire compartment and constituting the potential fire load would have to be accompanied by the sufficient availability of the combustion supporting oxygen, reaching the fire compartment via the numerous and permanently open gates. The analysis performed in this paper seems to indicate, that for large shopping halls a properly numerically modeled localized fire is more appropriate. This statement is in agreement with earlier recommendations of the authors, contained in [7]. A detailed analysis of fire plume temperature maps, similar to the maps presented in figures 4 and 5 above and obtained for the scenario B of fire development at low stacking height, after 60 minutes of fire exposure and related to the authoritative cross section of the larger of considered halls (figure 3), suffices to support this statement. The relevant maps are presented in Figures 8, 9 and 10, beginning with maps obtained for hall with operating smoke vents. The map depicted in Figure 8 shows the situation at the cross section located between the smoke vent axes (this location is shown as well in Figure 3), while the map shown in Figure 9 depicts the situation at the cross section located along the vent axes. Figure 10 presents the same maps for the analogous hall devoid of any smoke vents. The isotherm depicted in black denotes the temperature of 100°C.

**Figure 8.** Scenario B – map of fire plume temperature obtained after 60 minutes of fire exposure in the larger hall with operating smoke vents in the cross section located between the vent axes. The isotherm depicted in black denotes the temperature of 100°C.

**Figure 9.** Scenario B – map of fire plume temperature obtained after 60 minutes of fire exposure in the larger hall with operating smoke vents in the cross section located along the vent axes. The isotherm depicted in black denotes the temperature of 100°C.

**Figure 10.** Scenario B – map of fire plume temperature obtained after 60 minutes of fire exposure in the larger hall without smoke vents in the cross section located as in figure 8. The isotherm depicted in black denotes the temperature of 100°C.

Comparison of maps depicted in Figures 8, 9 and 10 with corresponding maps depicted above in Figures 4 and 5 should be made keeping in mind, that the larger hall considered in the scenario B is significantly higher (7.00m) than the smaller one considered in the scenario A (4.50m). With the same stacking height of combustible materials (derivatives of cellulose) assumed for both halls (3.50m) this results in a much larger open space, devoid of any obstacles such as shelves, located directly under the ceiling. Those 3.50m of open space under the ceiling in the scenario B kept the fire modeled in the larger hall during the whole 60 minutes of fire exposure at the stage of localized fire. The thickness of hot fire plume under the ceiling even after one hour of intense fire action proved to be insufficient to initiate ignition of combustible materials located on the racks below in the nearest vicinity of the fire source. Within such scenario of fire development the operation of smoke vents did not substantially
affect the temperature of air near the floor level, and thus it did not affect the forecast occupant evacuation time. The maps of fire plume temperature obtained after 60 minutes of fire exposure at the height of 6.00m above floor level seem to corroborate the conclusion that the fire remained at the stage of localized fire. These maps are analogous to the maps depicted in Figure 6 for the smaller hall and the scenario A of fire development. The first of the compared maps, depicted in Figure 11 pertains to the case with operating smoke vents, while the second one pertains to the analogous structure but devoid of smoke vents (Figure 12). Comparison of both maps seems to indicate a slightly larger fire affected zone in the case of hall devoid of smoke vents with respect to the case of a hall equipped with operating smoke vents, though the difference does not seem to be significant from the standpoint of the safety level ensured to the users of the considered hall.

**Figure 11.** Scenario B – Fire plume temperature map obtained after 60 minutes of fire exposure at the height of 6.00m above the floor level in the larger of considered halls with operating smoke vents. The isotherm depicted in black denotes the temperature of 100°C.

**Figure 12.** Scenario B – Fire plume temperature map obtained after 60 minutes of fire exposure at the height of 6.00m above the floor level in the larger of considered halls without smoke vents. The isotherm depicted in black denotes the temperature of 100°C.

**Figure 13.** Scenario B – Distributions of fire plume temperature values obtained after 60 minutes of fire exposure in the cross section of the larger of considered halls at the height of 6.00m above floor level for the hall equipped with operating smoke vents and the hall devoid of such.
An additional confirmation of the locality of fire developing within the framework of scenario B after 60 minutes of fire exposure is offered by the analysis of fire plume temperature distribution obtained in the cross section of the large hall shown in Figure 3, at the height of 6.00m above the floor level. This distribution is depicted in Figure 13. The values of temperature forecast for the case of a hall equipped with operating smoke vents and for the same hall devoid of smoke vents seem to indicate, in both cases, a clearly defined maximum of the temperature in the nearest vicinity of the flame constituting the initial source of fire accompanied by rapid decrease of simulated fire plume temperature with increasing distance to the fire source. The shapes of both graphs are thus substantially different than the shapes of graphs depicted in Figure 7 and obtained for the scenario A and the smaller of the considered halls. Let us note, however, that the difference between the results obtained for the larger hall equipped with smoke vents, and the same hall devoid of such is now in general negligible [8, 9].

3.3. Scenario C

The scenario C differs from the scenario B analyzed for the large hall only in that the stacking height of the combustible materials has been changed from 3.50m to 5.50m. The spatial distribution of the racks has not been changed in any way. The parameters determining the ignition chances of goods placed on these shelves have not been changed in any way as well. This means that in this case the volume of empty space above the racks, where the fire plume may freely propagate is much more restricted. At the same time, due to the added amount of combustible materials, the fire load in the fire compartment has been substantially increased. Because of that, even at the same power of a fire source initiating the fire as in the scenario B, in the scenario C a local ignition of the combustible materials stockpiled in the hall is much more probable and in turn the cascading propagation of a fire to the neighbouring storage racks is more probable as well. In Figures 14 and 15 the fire plume temperature maps are depicted for the scenario C, after 60 minutes of fire exposure, obtained in the same cross sections of the considered hall as before. These maps correspond to the analogous maps depicted in Figures 8, 9 and 10. The 100°C isotherm is depicted in black in those pictures as well. The map from Figure 14 refers to the cross section located between the smoke vents, while the other one, from figure 15, refers to the cross section located along the axes of smoke vents. The scenario for a hall devoid of smoke vents has not been considered here. The maps of Figures 14 and 15 are accompanied by the maps of fire plume temperature distributions obtained for the scenario C and referring to the cross section at the height of 6.00m above the floor level. These maps are analogous to those depicted above in Figures 8, 9 and 10 referring to the scenario B. These maps are presented in Figures 16 and 17, to depict the simulated fire development in the scenario C after 30 minutes (Figure 16) and 60 minutes (Figure 17) of fire exposure. One may easily notice, that in this scenario, in spite of smoke vents acting to slow the progress of fire, only after 30 minutes of fire exposure the fire engulfed a substantial part of the affected hall. Thus the fire development happened to progress in a much faster pace than in the case identified for the scenario B.

Another important difference between the distribution of fire plume temperature obtained in the same cross section of the same large hall after the simulation of fire corresponding to the assumptions of the scenario C, with respect to the analogous distribution obtained previously for the scenario B is depicted in Figure 18. One may notice, after juxtaposition with the results depicted in Figure 13, that this time the maximum forecast fire plume temperature proved to be much higher than previously. Nevertheless, the simulated fire remained within the characteristics of a localized fire, with definite maximum at the axis of initial flame indicating the source of the fire. The higher forecast maximum temperature seems to be the result of increased stacking height with respect to the scenario B. In the scenario C the hot fire plume under the ceiling reaches the tops of storage racks much earlier than in the scenario B, and this in turn increases the possibility for cascading progress of fire to the new locations in the considered hall [10].
Figure 14. Scenario C - Exhaust plume gas temperature maps obtained after 60 minutes of a fire exposure in the case of a larger hall equipped with smoke vents, for the cross section of the hall located between the smoke vent axes. The isotherm depicted in black denotes the fire plume temperature of 100°C.

Figure 15. Scenario C - Exhaust plume gas temperature maps obtained after 60 minutes of a fire exposure in the case of a larger hall equipped with smoke vents, for the cross section of the hall located along the axes of smoke vents. The isotherm depicted in black denotes the fire plume temperature of 100°C.

Figure 16. Scenario C – Map of fire plume temperature values obtained after 30 minutes of fire exposure in the horizontal cross section of the larger hall located at the height of 6.00m above floor level under the assumption, that the hall had been equipped with operating smoke vents. The isotherm depicted in black denotes the fire plume temperature of 100°C.

Figure 17. Scenario C – Map of fire plume temperature values obtained after 60 minutes of fire exposure in the horizontal cross section of the larger hall located at the height of 6.00m above floor level under the assumption, that the hall had been equipped with operating smoke vents. The isotherm depicted in black denotes the fire plume temperature of 100°C.

4. Influence of the limited effective ventilation in the case of fire

The juxtaposition of graphs depicted together in Figure 7 unequivocally indicates that during simulation of fire in a small hall, corresponding to the scenario A, in the case of a hall equipped with operating smoke vents, the fire plume temperature at the considered level proved to be much higher than the analogous temperature forecast for the same hall devoid of any smoke vents. So strong differentiation may be attributed to the fact that in the second case the fire intensity was strongly affected by the limited availability of the combustion supporting oxygen [3]. The oxygen could, in this scenario, reach the fire zone only via the relatively distant constantly open access gates. Thus in this case the fire development was typical for the ventilation driven fires, as opposed to the case of the larger hall and the scenario B, where the fire was driven by the availability of the combustible material. This conclusion seems to be corroborated by the juxtaposition depicted in Figure 19. This figure presents the changes in the fire plume temperature measured at a point located at the distance of 3.00m from the initial source of fire and at the height of 4.00m above the floor level. This graph indicates, that in the case of a hall equipped with operating smoke vents the temperature averaged in the random process of burning progressed in general monotonically during the whole hour of analyzed fire exposure. The results obtained for the same hall, but devoid of vents indicate a completely different progress of fire. This time the fire plume temperature measured could not reach the sufficiently high level, and subsequently increase even further in analogy to the scenario considered.
previously, due to the limited availability of the oxygen extracted from the surroundings of the hall. Thus the temperature after initiation rapidly decreased, due to the momentary “suppression” of fire, and subsequently stabilized at the level of equilibrium conditioned by the available effective ventilation of the fire compartment [8, 9].

![Figure 18](image.png)

**Figure 18.** Distributions of fire plume temperature values obtained after 60 minutes of fire exposure in the cross section of the larger hall at the height of 6.00m above the floor level under the assumption, that the smoke vents operate efficiently. The lower graph pertains to the scenario B of the simulated fire, while the upper one pertains to the scenario C.

Analysis of analogous juxtaposition depicted in Figure 20, this time related to the scenario B of the fire and the larger of the considered halls, leads to a completely different conclusion. As one may observe, in the case of those simulations the forecast fire plume temperature increased monotonically both in the case when the hall was equipped with smoke vents, as well as when the hall was not so equipped. Thus here the suppression of fire did not occur. Anyway it would be difficult with so large volume of the fire compartment. The fire plume temperature increased rather slowly in this case. The faster increase in the temperature would be here a result of cascading progress of fire to adjacent storage racks containing combustible materials and located at the increasing distance to the initial source of flame. Therefore, if in the presented simulation there were no conditions for increasing fire development intensity, then it must mean that only the energy released in the localized fire, affecting the limited volume of the fire zone, contributed to the increase in the exhaust gas temperature [8, 9].

The juxtaposition depicted in Figure 21 illustrates another important difference in fire development modes in the larger of analyzed halls. This difference clearly distinguishes the development typical for the scenario C from the one observed when the scenario B is considered. The course of curves depicting the increase in the temperature of fire plume identified at the distance of 3.00m from the vertical axis indicating the location of the initial flame is different here. As far as the scenario B is considered opening of the smoke vents in general did not affect the progress of fire, as the generated heat proved to be insufficient to ignite the combustible materials gathered on the nearest storage racks adjacent to the initial flame source, while the fire corresponding to the scenario C, due to the increased stacking height, was capable of progressing from storage rack to the adjacent storage rack in a
cascading mode. In such case the fire in the considered location developed rapidly, in general in a monotonous manner, and the unlimited availability of the oxygen entering the fire affected area was assured via the opened smoke vents. Thus there was no question of possible fire suppression [10].

**Figure 19.** Scenario A – Changes in fire plume temperature determined for the fire in the smaller of considered halls at a point located 3.00m from the initial flame axis at the height of 4.00m above the floor level. In the case of a hall equipped with operating smoke vents the monotonous increase of averaged measured fire plume temperature is observed during the whole analyzed fire exposure time. For the hall devoid of vents the effects of suppressed combustion intensity typical for fires driven by ventilation conditions are visible.

**Figure 20.** Scenario B – Changes in the exhaust plume gas temperature obtained inside the bigger of considered halls in a location at the distance of 3.00m from the initial fire axis and at the height of 6.00m above floor level.
Figure 21. Changes in the exhaust plume gas temperature obtained inside the bigger of considered halls in a location at the distance of 3.00m from the initial fire axis and at the height of 6.00m above floor level – comparison of results obtained after simulation of fires developing under assumptions of scenarios B and C.

5. Concluding remarks
The results of simulations presented here seem to support the initial assumption, that for large area shopping halls, having a specific geometry, limited availability of efficient ventilation and more or less uniform distribution of combustible materials constituting the fire load, the localized fire of limited intensity may prove to be the authoritative one for identification of fire safety. Assumption of such reference fire instead of classical and commonly applied fully developed fire model, characterized by uniform distribution of temperature in the whole affected fire compartment, may allow for substantial savings gained in the process of rational selection of active and passive fire protection means. It has to be underlined here, that the more economical selection of the protection resources should be permitted only if the evaluator, despite recommended reductions, could justify the statement on guaranteeing the users of the hall the required safety level. Thus the Authors of this paper postulate, in the practically and economically justified cases, to approach in a less formal and more individualized manner the problem of specifying the required fire protection scheme. In our understanding this should be manifested by the selection of fire protection resources based on the qualitative and quantitative evaluation of risks supported by the assumption of a reliable and well justified authoritative fire development scenario followed by a detailed numerical analysis instead of schematically applying the conventional recommendations prepared for a wide spectrum of structures often substantially differing in the enclosed volume, shape and dimensions as well as mode of operation. Parameters of such a model are usually determined not only by the hall geometry, known a’priori, but also by the real hall ventilation capabilities, especially in the case of fire initiation, as well as by the quality and quantity of the accumulated merchandise representing the potential fuel and constituting the fire load. In the authors’ opinion the numerical simulation of a fire development performed within the framework of FDS computer code presents an efficient computational tool allowing for reliable prediction of the most unfavourable, but at the same time probable fire scenario, which may be realized in the given design situation.
6. References

[1] Biczysk A., Maslak M., Kwasniewski L., Lukacz M., 2012, Fire in a large-area shopping center, in: Wald F. et al. (Eds.) – COST Action TU0904, Integrated Fire Engineering and Response – Case Studies, CTU Publishing - Production, Czech Technical University in Prague, March 2012, 131-139.

[2] Maslak M., Pazdanowski M., Wozniczka P., 2017, Impact of the limited oxygen availability on the localized fire development in a large-area building compartment, Proceedings of the International Scientific Conference „Fire Protection, Safety and Security 2017”, Zvolen, Slovakia, May 3-5, 2017, 99-109.

[3] Maslak M., Wozniczka P., 2017, Scenariusze rozwoju pożaru w wielkopowierzchniowej hali handlowej – część 1, Nowoczesne Hale, 1/2017, 27-31.

[4] Maslak M., Wozniczka P., 2017, Scenariusze rozwoju pożaru w wielkopowierzchniowej hali handlowej – część 2, Nowoczesne Hale, 3/2017, 64-67.

[5] Wang Y., Burgess I., Wald F., Gillie M., 2014, Performance-based fire engineering of structures, CRC Press, London.

[6] McGrattan K., Hostikka S., McDermott R., Floyd J., Weinschenk C., Overholt K., 2013, Fire Dynamics Simulator user’s guide, NIST, Gaithersburg, Maryland, USA.

[7] Fan Shen-Gang, Shu Gan-Ping, She Guang-Jun, Liew Richard J.Y., 2014, Computational method and numerical simulation of temperature field for large-space steel structures in fire, Advanced Steel Construction, 10(2), 2014, 151-178.

[8] Maslak M., Pazdanowski M., Wozniczka P., 2017, Temperature distribution in a large-area shopping hall in the case of a localized fire, in: Nigro E., Bilotta A. (Eds.) – Proceedings of the 2nd International Fire Safety Symposium (IFireSS 2017), Naples, Italy, June 7-9, 2017, 853-860.

[9] Maslak M., Wozniczka P., 2017, The impact of the fire source location on fire development in a large-space steel commercial building, Safety & Fire Techniques, 45(1), 2017, 154-169.

[10] Maslak M., Wozniczka P., Pazdanowski M., 2018, Forecast of a fire spreading in a large-area shopping hall, Technical Transactions, 12/2018, 61-76.