SOME FACTORS INFLUENCING CONSTRUCTION OF IMPROVIZED SHELTERS

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Abstract

The article deals with improvized collective protection shelters designed to protect inhabitants in times of crisis and disasters. It provides information about some factors influencing construction of these shelters. The article pays attention to harmful effects which might affect population, and their impact on the location of improvized shelters. It furthermore deals with weather conditions and how they affect the construction. The article also mentions the structure of facilities in which improvized shelters are built.

Key words

Improvized shelter, harmful effects, weather conditions, airtightness of buildings, interior microclimate.

INTRODUCTION

Act No. 239/2000 Coll. on integrated rescue system as amended imposes among others the municipality authorities the obligation to ensure sheltering of persons against impending danger (see § 15 subsec. 1 and § 15 subsec. 2 letter c). One of the possibilities how to fulfill this task are improvized shelters.

Improvized shelter (IU) is a beforehand selected or beforehand technically prepared optimal space in suitable parts of apartments, apartment buildings, operational and production facilities which will be adapted (before the rise of extraordinary events or imminently after their occurrence) by physical and legal persons for their protection and for the protection of their emploees against the effects of extraordinary events using their own material an financial sources.

Construction of improvized shelters belongs among the simplest and fastest ways of effective sheltering of population.

A wide range of factors influences the construction of improvized shelters. The most significant ones are:

- the kind of harmful effects affecting the population in case of the rise of extraordinary events (kind of hazardous chemicals and their chemical and physical properties, their concentration and their operating time),

- weather conditions which are within the area of an extraordinary event (MU) and within the area of the IU build-up, first of all the wind speed, wind intensity, wind direction and disperse conditions,
- the difference of the temperatures between the inside space of an improvized shelter and outside space (area where the extraordinary event occurs),
- the number of windows and doors which are in the space of the shelters, their size, shape and structuring, used material and production technology of these windows and doors, their infiltration property,
- construction airtightness in the building where the improvized shelter is intended,
- internal capacity of a room which serves as an improvized shelter, the number of persons sheltered in this room and relevant requirements for the interior microclimate in this improvized shelter,
- distribution of rooms of an improvized shelter in the facility both horizontal placement with regard to peripheral walls of the object, and vertical placement (basement or higher floors of a facility).

1 POTENTIAL HARMFUL EFFECTS

When solving the issue of improvized sheltering it is necessary to realize the fact that on the CR territory a large number of various hazardous materials has been produced, stored, transported and technologicly elaborated and under certain circumstances their escape might occur. The range of these injurants might increase in case of terrorist attacks or in case of nationwide exposure to danger and under the war state with the potential involvement of poisonous substances.

Another fact which must be taken into account during the construction of IU is the likelihood of threatening the population with atomic irradiation. On the CR territory there are several nuclear power plants and other facilities where radioactive material is being processed. Security of these facilities is on a very high level; nevertheless, our obligation is to prepare also for less probable extraordinary situations in these facilities. Population can be endangered also during the transportation of radioactive materials. Another possibility to threaten with atomic irradiation is a terrorist attact with the use of so called dirty bombs or the use of weapons of mass destruction under the nationwide exposure to danger and under the state of war.

1.1 Kind of dangerous chemical substances, their properties, operating time and concentrations

In case of a dangerous chemicals escape (thereinafter injurants) it is necessary to take into consideration that the escape of injurants might occur right away and whenever, that the extent of the escape basically cannot be determined beforehand and that the injurants will operate as vapours and gases and in the vicinity of the escape also as liquids and that the contamination of the territory in this vicinity might occur in a very short time.

During an accident in the facility where the dangerous injurants abound (magazines, tanks, apparatuses, cross-ignition tubes), also the escape of these injurants might occur with the speed which depends on a wide range of factors. During the escape of the injurants a strong circulation of dust particles which bind toxic substances happens. This toxic cloud of dust, gases and vapours spreads in the wind direction. The size of contaminated territory depends on the amount and the speed of the injurant outflow, on physical, chemical and toxic properties of a substance, on meteorological conditions and the shape of the terrain.

1.1.1 Properties of chemical injurants and their concentrations

Potentionally the highest danger for the population is **chlorine, ammonia, methanal and hydrogen cyanide**. Among other dangerous injurants we can range **fosgene, sulphur dioxide, sulphide, carbon disulphide, phosphoric chloride, nitration gases etc**.

One of the basic parameters of the improvised shelters issue is the concentration of these injurants and their operation time both in the outside and first of all in the inside environment. The following table no. 1 specifies acceptable exposition limits (PEL) and the highest acceptable concentrations (NPK-P) of some dangerous injurants according to valid hygienic regulations (e.g. Government resolution no. 361/2007 Coll., which sets the conditions of health protection at work).

Exposition limits are for the entire shift, timely weighed averages of gases concentrations, vapours or aerosols to which, according to current knowledge, the employees might be exposed during the 8-hour working shift.

The highest acceptable concentrations of chemical substances in the working environment are such concentrations to which any employee must not be exposed during the working hours.

When selecting an appropriate space for improvized sheltering we have to take into consideration also specific physical and chemical properties of injurants against which the shelters are to protect, especially whether these injurants are lighter or heavier than the air. From this viewpoint we can divide the injurants into three cathegories:

- ammonia and hydrogen fluorine are lighter than the air and will raise to higher layers of the atmosphere;
- hydrogen cyanide and methanal are approximately as heavy as the air;
- chlorine, phosgene, sulphide, carbon disuphide, sulphur dioxide and hydrogen chloride are heavier than the air and will stick to the ground.

In this connection it is necessary to commemorate that heavier than air are also all known poisonous substances and bacteriological (biological) agents.

Table 1
Acceptable exposition limits (PEL) and highest acceptable concentrations (NPK-P)

Agent	Number CAS	PEL [mg.m^{-3}]	NPK-P [mg.m^{-3}]
Ammonia	7664-41-7	14	36
Phosgene	75-44-5	0,08	0,4
Methanal	50-00-0	0,5	1
Chlorine	7782-50-5	0,5	1,5
Phosphoric chloride	7719-12-2	1	3
Hydrogen cyanide	74-90-8	3	10
Nitration gases		10	20
Sulphur dioxide	7446-09-5	5	10
Carbon disulphide	75-15-0	10	20
Sulphide	7783-06-4	10	20

1.1.2 Operation time of hazardous chemicals

The operation time of dangerous chemicals will depend on the duration of an accident and on the duration of its liquidation. In the vicinity of the center we predict the operation time of high concentrations of injurants 24 hours and more. In remote places which are threatened by a toxic cloud and instantaneous evaporation, the times will be substantially shorter – from 1 hour to several hours.

The operation time of an injurant during the inversion states of the air takes several days as long as there is not the change of meteorological conditions. Concentrations of injurants are considerably lower, though.

1.2 Atomic irradiation

The issue of atomic irradiation is very extensive and complex. When simplifying this issue, atomic irradiation propagates from its source in a straight line in all directions and is capable to penetrate also into strong layers of materials (this pays for gamma irradiation). During the penetration through the material, the irradiation weakens. Alfa irradiation might be weaken even by a sheet of paper, to shade beta irradiation we need a layer of the air of 1 meter or iron 1 mm thick. To absorb gama irradiation we need a huge mass of materials. More suitable are materials with a higher atomic number and high density. For example 1 cm of lead decreases the intensity of gamma irradiation by 50 %, when going through a layer of concrete 6 cm thick, the intensity will be half-size.

The total value of all factors influencing protective properties of a construction against atomic irradiation is called protective coefficient of a construction or coefficient of construction protection and is marked „K_o“.

Protective coefficient of a construction $\mathbf{K_o}$ determines how many times the dose of atomic irradiation in a shelter D_u (the level of irradiation P_u) is lower than the dose of atomic irradiation 1 m above the outside terrain D_o (the level of iradiation P_o) providing that the fallout is evenly distributed in horizontal areas and the fallout in vertical areas is not considered.

$$K_o = \frac{D_o}{D_u}, \qquad K_o = \frac{P_o}{P_u}$$

Protective coefficient of a construction K_o is dependent first of all on surface mass of the outside and inside walls, on surface mass of ceiling constructions, on surface mass of fillings, on the area and the height of windows and other openings in circuit walls, on the size of rooms and the depth of the floor setdown. Calculation of K_o is made according to the formulas contained in the regulation MO CO-6-1. For permanent shelters of civil protection it is required that the protective coefficient of the building was at least 50. In reality, in most permanent shelters K_o is 200 and more, i.e. the dose of atomic irradiation decreases 200 times and more.

Surfase mass of outside and inside walls, surface mass of ceiling constructions and surface mass of fillings are the main factors influencing the size of the protection coefficient of a building and it is expressed by kg/m^2.

People must be protected both, against propagating irradiation after the explosion of a nucler weapon or after the breakdown of a nuclear facility or other strong source of irradiation, and against radioactive contamination from the fallout where the bearer is radioactive dust of various composition which gradually falls from a radioactive cloud. In the building, persons are exposed to various kinds of radiation:

- direct radiation – penetrates from the terrain level through windows into a building;
- radiation dispersed by the air – it penetrates from the air through windowns into a building;
- radiation dispersed and weakened by walls, roof and ceiling construction;
- radiation absorbed by ground.

Therefore, against the external radiation, the space in the middle part of a facility embedded as much as possible in the surrounding terrain is appropriate. The most convenient space is in facilities with heavy enclosure walls and with the least surface of window and other constructions openings.

2 WEATHER CONDITIONS

Weather conditions which are in the area of an extraordinary event and in the area of an improvised shelter represent an important factor which might significantly influence improvized sheltering of population. A significant role in this case will rest on the wind first of all, dispersion conditions, and the difference of the temperatures between the inside and outside space.

2.1 Wind – its speed, intensity, and direction

Wind is the horizontal flowing of the air in the atmosphere and has three main characteritics - direction, speed and power (intensity).

The direction of the wind depends on the prevailing direction from which the wind flows – more precise determination using the azimuth (0 – 360^o) or in the meteorology using world quarters (basicly with the accuracy of 22,5^o, i.e. the differentiation e.g. north, north-northeast, northeast, east-northeast and east direction).

Speed of the wind means the velocity of the movement of aerial mass in the terraine (it is measured with regard to the earth), it is classified either by accurate determination of its speed (km/hour, m/second, mile/hour), or in degrees which are determined approximately according to the Beaufort scale. The wind intensity corresponds with the speed according to the table no. 2. The wind power can be estimated alongwith the following attributes:

- CALM – smoke rises vertically up,
- BREEZE – the wind direction is recognizable according to the smoke movement, the wind does not move the wind vane, though,
- LIGHT WIND – the wind feels in the face, the leaves of trees murmur, the wind cane starts moving,
- MILD WIND – the leaves of trees and twigs are permanently moving, the wind blows the small flags and slightly curls the standing water surface,
- FAIRLY FRESH WIND – the wind rises dust and strips of paper, moves thinner branches,
- FRESH WIND – leafy bushes start moving, on standing water smaller waves with foamy crests occur,
- STRONG WIND – the wind moves thicker branches, telegraph wires whizz, using umbrellas is difficult,
- SHARP WIND – the wind moves the trees, walking against the wind is difficult,
- WILD WIND – the wind breaks branches, walking against the wind is almost impossible,
- STORM – the wind causes minor damage to constructions (pulls chimneys, roof tiles),
- HEAVY STORM – is rare on the ground, it uproots the trees, causes major damage,
- MIGHTY STORM – is very rare, it causes large damage to houses, forests,
- HURRICANE – the wind is very destructive (it takes off houses, moves heavy things).

The change of the wind direction or speed can be expressed as follows: shifts, turns, intensifies, weakens etc.

The wind can for a short term (in blasts) substantially increase ists speed. In such case we talk about wind blasts. Wind blast is measured by meters/second The criterion for the wind blast is the exceeding of the average by 5 m/s during at least 1 s; however 20 s at most. The lowest determined boundary of the wind blast is 12 m/s; nevertheless for the wide public the boundary is from 15 m/s.

Table 2
Wind speed and intensity

Wind category	**Beaufort scale**	**Speed [km/h]**	**Speed [m/s]**
Calm	gnumber 0 and 1	0 - 5	0 - 1,4
Light air	grade 2	5 - 10	1,4 - 2,8
Gentle breeze	grade 3	10 - 20	2,8 – 5,6
Fresh breeze	grade 4 and 5	20 - 35	5,66 - 10
Strong breeze	grade 6	35 - 55	10 - 15
High wind near Gale	grade 7 and 8	55 - 75	15 - 21
Strong Gale/Storm	cgrade 9 and 10	75 - 110	21 - 30
Hurricane	grade 11 and 12	over 110	over 30

The speed of the wind influences the pressure conditions outside the buildings. Usually we count with the wind speed of 1 – 8 m/s. If there is the wind (horizontal flow of the wind) on the windward side, there is a specific overpressure and on the leeward is specific underpressure. This fact shows the way, that in the room on the windward side there is the increased pressure on the windowns and doors and therefore also increased air exchange especially through the windows and doors joints. So called values of the air exchange factor [l $hour^{-1}$] are in this case high. Lower values of the air exchange factor will be in the room in the middle part of a building and the lowest in the room on the leeward of the building.

For illustration we can notice that e.g. providing that the size of the air exchange factor in the room on the windward side is 0,25 l per hour, we can assume that in the room in the middle part of the building the size of this factor will be 0,15 l per hour and in the room on the leeward the factor will be 0,10 l per hour. The values of the air exchange factor can be calculated or are determined experimentally. From the above mentioned, it is obvious that the differences in the air exchange in room on windward and leeward sides are quite big. This fact will have a substantial influence during the decision making on a ground floor plan of an improvized shelter in a building.

Through long-term monitoring of the wind direction, first of all in meteorologic workplaces we obtain another data which are important also for improvized sheltering. This data is the information on prevailing direction of the wind. It generally pays that the room for improvized sheltering of population is to be chosen on the side of a bulding which is reverse to prevailing wind direction in a specific location.

Regarding improvized sheltering, we can also say that in relation to wind speed the wind with higher speed has two effects.

The first effect is for improvized sheltering unfavourable – the higher speed of the wind, the bigger is the pressure on the entire area of windows and doors and the higher probability that the injurant will penetrate into the windows and door joints inside the improvized shelter.

The second effect is from the viewpoint of improvized sheltering favourable – the higher is the speed of the wind, the faster the injurant is dispersed in the outside environment and therefore the faster is the decline of the injurant concentration in the area.

2.2 Disperse conditions

Disperse conditions are meteorologic conditions for the spread of pollutants in the air. It depends especially on the flow of the air in both horizontal and vertical direction. We define 3 kinds of disperse conditions:

- Good spreading conditions - in the height of 1000 to 1500 meters above the ground there is no retention layer which would limit the spread of injurants. In case of the altitude retention layer, the spreading conditions also depend on the speed of the wind under the lower boundary of a retention layer.
- Slightly unfavorable spreading conditions - the retention layer with regard to the wind speed limits the possibility to spread injurants; however it does not cover the parameters of either favorable or good disperse conditions.
- Unfavorable disperse conditions – the state when the spread of addition agents in the atmosphere is almost impossible and which will cause long-term significant exceeding of emission limits in the area with the sources of pollution. This state of disperse conditions occurs when there is a huge retention layer in the altitude up to 1000 meters above the ground in combination with weak or no circulation.

2.3 The difference of temperatures between the inside and outside space

Construction of improvized shelters is influenced also by the difference of temperatures between the inside and outside space. Due to the difference of temperatures between the inside and outside space there is the natural movement of the air thanks to different density of the air. The division of the pressure deduced from the effects of the temperature difference in a heated room is in the figure no. 2.

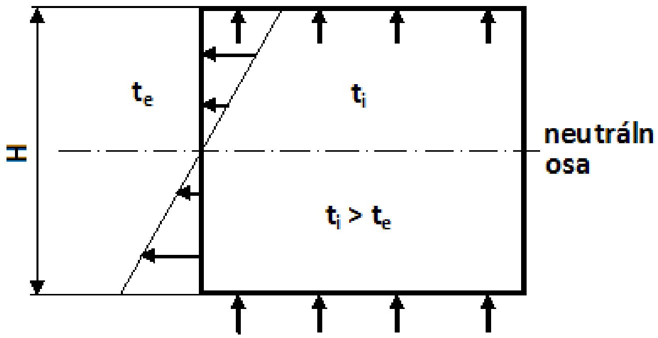


Fig. 2
Division of the pressure in a room due to the temperature difference effect

The difference of the pressure increases linearly with the ascending distance from a neutral level. In the upper part of the room the inner overpressure affects the dividing wall and the outer overpressure is on the floor (where t_e is the outside temperature, t_i is the inside temperature, H is the height of a room).

3 WINDOWS, DOORS AND OTHER CONSTRUCTION OPENINGS IN IMPROVIZED SHELTERS

When choosing a suitable place for improvized sheltering it is very important to take into consideration future adjustments which will have to be made during construction of improvized shelters. First of all it means to assure sufficient surface mass with window and all other construction openings together with necessary airtightness of these openings. Therefore for the construction of improvised shelters should be used places with small surface of construction openings or even without them. The less door, window and other openings, the less time and labor consuming it will be during the construction of these improvized shelters.

3.1 Applied materials and the technology of the windows and doors construction

A significant factor that is important also in case of improvized sheltering is the fact that at present the insulation of buildings has been made in a massive scale. This initiation of building owners brings among others the improvement of warm-insulation properties of this way adapted buildings. It brings also better properties of buildings usable for protection of population. The facades remake and their insulation improve significantly the airtightness of enclosure walls and lining. This way such buildings significantly improved the values of the air exchange factor.

Generally, within buildings insulation also old, mostly wood, from the viewpoint of airtightness very bad quality windows and doors are changed.

Generally pays that with old wood windows (e.g. a wood double window, with fittings TOKOZ which were mostly used in old panel (prefab) buildings) the reference airiness with regard to a total surface of a window is about 50 $m^3/h.m^2$. The reference airiness with regard to the whole length of the window joints is around 12 $m^3/h.m$. This reference airiness is very high, therefore these windows are in the lowest classes with regard both to the total surface, and the length of the joints (generally class 0 or class 1).

Current windows and doors are generally substituted by plastic or wood windows e.g. Euro-windows. Both plastic windows and doors, and Euro-windows have very good tightness against the outside area. Their airiness is very low i.e. in case of the escape of industrial pollutants from the outside (contaminated) environment only a small amount (or even nothing) gets inside through window and door joints. It pays also when the pollutants due to the wind are pressed through the windows and doors. The volume of this pressure with regard to the wind speed is demonstrated in table no. 4, e.g. wind speed 45km/h (2,5 m/s) causes 100 Pa (10 mm CE) pressure on the window surface.

Reference airiness of these windows with regard to the whole window surface is about 3 $m^3/h.m^2$ and the total length of the window joint about 0,75 $m^3/h.m$, i.e. many times lower than in case of older windows. These windows are highly classified both with regard to the whole surface, and the length of the joint (generally class 4).

Table 4
The volume of experimental pressures on the window surface in conversion to the wind speed

Pressure [Pa]	**Pressure [mm CE]**	**Wind speed [km/h]**	**Wind speed [m/s]**
40	4	29	8,1
100	10	45	2,5
150	15	56	15,6
200	20	66	18,3
300	30	79	21,9
400	40	91	25,3
500	50	102	28,3
600	60	112	31,1
750	75	125	34,7
1000	100	144	40,0
1250	125	160	44,4
1500	150	175	48,6
2000	200	205	56,9
3000	300	250	69,4

The review of windows and doors classes with regard to reference airiness related to the total surface of windows and doors and the length of the joints of windows and doors is given in table no. 5.

One of the conclusions of measurements and experiments carried out at Population Protection Institute in Lazne Bohdanec is the fact that if there is suitably chosen and well done additional tightness of older wood windows, it is possible to improve the classification with regard to both the total surface, and the length of the joints from class 0 to class 4, i.e. from the lowest class to the highest one. Even in case of an older wood window it is possible to achieve through additional tightening the same tightness as it is in case of more modern types of windows.

Table 5

The range of classes of windows and doors with regard to reference airiness

Class	**Reference airiness of 100 Pa related to the total surface [$m^3/h.m^2$]**	**Reference airiness of 100 Pa related to the joint length [$m^3/h.m$]**
0	Is not tested	
1	50	12,50
2	27	6,75
3	9	2,25
4	3	0,75

4 AIRTIGHTNESS OF BUILDINGS

Airtightness of buildings where we build improvized shelters is the determining element for the penetration of dangerous agents from the outside atmosphere into internal parts of these constructions.

Therefore to ensure the airtightness of protected space (improvised shelter) against the outside environment, i.e. maximal decrease of natural air exchange which is called infiltration belongs to the most important tasks when building the improvized shelters.

Air infiltration (l) is a natural air exchange which occurs due to the untighteness of constructions and the untighteness of construction openings.

The highest proportion in infiltration of buildings belongs to the joints in constructions themselves and to the fillings of construction openings, first of all of windows and doors. The total length of the joints is dependent on the size and the number of windows and doors and on the airtightness which is expressed by so called coefficient of airiness. The coefficient of airiness of joints depends e.g. on the quality of doors and windows off-setting into a building. Its values are for individual types of windows and doors very different. The worst windows are single wood windows and wood frames, the best airtightness embodies Euro-windows and plastic windows. The coefficient of airiness gets worse with the age of buildings.

With regard to the decrease of infiltration we recommend to locate the shelters into rooms with smaller windows and with a small number of doors.

Based on practical measurements and calculations the air exchange in buildings is from l = 0,1 to 2(1/h). For improvized shelters we consider the infiltration from I = 0,1 to 0,8.

With regard to the air infiltration we can specify the space in buildings as follows:

- Spaces with I = 0,8 are common spaces with wood doors and windows where the tightening is made of current sealing. In constructions are no untightened construction air holes, e.g. chimneys, shafts etc.
- Spaces with I = 0,3 are spaces with plastic or iron windows and doors with iron frames and rubber sealing. The whole external cladding of a building is sealed. They are so called insulated blocks of flats, houses, apartments in new buildings, new office buildings etc., where the cladding is tighter and ventilation operates through various regulated holes in plastic windows or through forced under-pressure ventilation. Besides sealing of ventilation openings and air holes it is necessary to tighten also permeation of plumbing (water, cables etc.).
- Spaces with I = 0,1 means already exceptional airtightness which responds to gas-tightness of standing gas-proof shelters. Improvized shelters must be equipped with special construction elements, first of all perfectly sealed plastic windows with ventilation openings for current use and perfectly sealed doors. Forced ventilation must be installed for current use in office buildings or civil buildings.
- Spaces with I = 1 up-to 2 are technically inconvenient buildings or wrong built (slapdash) buildings.

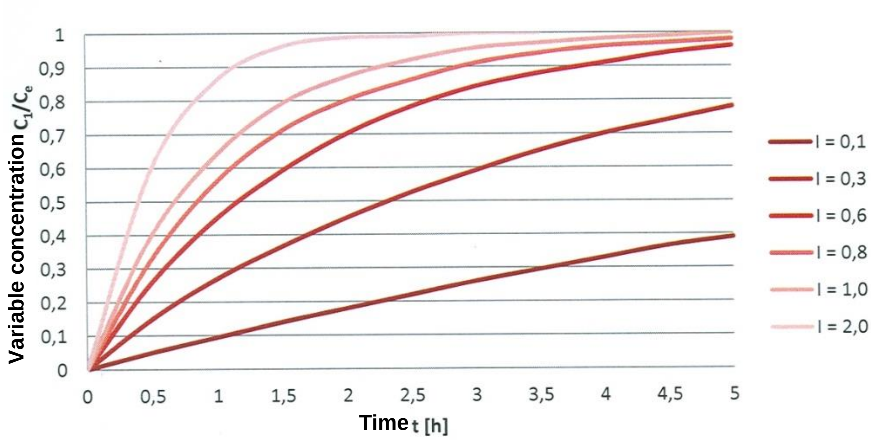
In case of the escape of a dangerous agent it is possible, based on the above mentioned facts and the specification of entry parameters, to determine the time path of the injurant concentration which will penetrate inside an improvised shelter.

The increase of the injurant concentration inside an improvised shelter is determined by:

$$\mathbf{C_i = C_e \,.\, (1 - e^{-t.I})\ \ [mg/m^3]}\ ,$$

where:

C_i – is the concentration of the injurant inside an improvised shelter [mg/m^3];
C_e – is the concentration of the injurant outside an improvised shelter [mg/m^3];
t – is time from the beginning of the experiment [h];
I – is the intensity of the air exchange [l/h];
e – constant (e = 2,71828).



Graph 1
Time path of the concentration of a dangerous agent inside an improvised shelter

Time increase of the concentration of a dangerous agent expressed by the relation C_i/C_e is shown in graph no. 1.

5 INTERNAL MICRO-CLIMATE

A very important factor which must be taken into account when constructing improvized shelters is the micro-climate inside an improvised shelter.

During the stay inside a closed space of an improvised shelter we face a limited flow of the outside air and the internal micro-climate gets worse. The decisive magnitudes for the evaluation of the quality of the internal environment are the values of volume concentration of carbon dioxide and the air temperature.

The highest acceptable parameters of internal micro-climate

- the highest temperature (of a damp thermometer) t_{efmax} = 30 °C;
- the highest concentration of carbon dioxide CO_2 = 2,5%;
- the lowest concentration of oxygen = 18%.

During the specification of an internal micro-climate we can use also the following basic data:

- the amount of breathed out carbon dioxide = 20 $l.os^{-1}.h^{-1}$;
- oxygen consumption = 25 $l.os^{-1}.h^{-1}$.

The calculation of the time path of carbon dioxide concentration can be made the same way as in case of the penetration of an injurant inside the shelter. The calculation starts from the known production of carbon dioxide by persons and from the infiltration.

The length of the stay of sheltered persons in a closed space can be determined also by the following relation:

$$t = \frac{C_{CO2} \cdot V}{100 \cdot m_{CO2} \cdot n},$$

where: t - Is the potential length of the stay of sheltered persons in a closed space [h];

V - Is the volume of a closed space in m^3;

n - is the number of sheltered persons;

m_{CO2} - Is the amount of carbon dioxide (CO_2) in m^3 breathed out by one person per hour (moves from 0,02 – 0,025 m^3h^{-1});

C_{CO2} - accepted increase of the CO_2 content in the air in %.

When calculating the length of the stay of sheltered persons in a closed space according to this relation we start from the presumption that in a closed space the natural exchange of the air (infiltration) is maximally decreased and that inside this space the fresh air is not delivered through e.g. filter-ventilation equipment.

6 PLACEMENT OF IMPROVIZED SHELTERS IN A BUILDING

The placement of suitable room for improvised shelters is chosen with regard to harmful effects which occur after the explosion of nuclear weapons or during the accidents of nuclear facilities and due to physical and chemical properties of dangerous agents against which they are to protect, especially whether these harmful agents are lighter or heavier than the air.

Space for improvised shelters can be divided according to its location and according to its protective properties against individual hazardous situations into three basic types.

1st type of improvized shelters

This type of improvised shelter is located in the basements of buildings and is suitable for protection against the external or internal radiation (inspiration of radioactive dust) after radioactive fallout.

Against the external radiation, the appropriate space is in the middle part of a building embedded as much as possible in the surrounding terrain. The most convenient spaces are in buildings with heavy enclosure walls and with the least surface of window and other constructions openings.

The decisive protective factor against external radiation is the surface mass of the external cladding and other walls, partition walls and ceilings separating the improvised shelter from external contaminated space. Not embedded enclosure walls in the basement must have the minimal thickness of brick construction 45 cm, stone 35 cm, an concrete 30 cm.

The entrance to an improvized shelter is always more suitable from the inside of the building than directly from the outside.

When selecting the space for IU of this type it is also very important to take into account necessary adjustments of IU. This means to ensure sufficient surface mass of window and all other construction openings at least on the level of in circuit walling. Therefore the best ones are the spaces with small surface of construction openings or even without them. This is suitable for another requirement which is sufficient gas-tightness of an improvized shelter. The less window and other openings, the less work during adjustments to an improvized shelter.

2nd type of improvized shelters

This type of IU is located in the basement parts of buildings and is determined for protection of population against industrial harmful agents lighter than the air.

This type is similar to the first type because it is located also in the basement. It differs due to the fact that the surface weight of cladding of the building is not important at all, just the sufficient gas-tightness. The total gas-tightness of the space can be enhanced by additional gas-tightness adjustments to construction openings and walls. As with the first type, the principle is that the less construction openings, the less work with their later sealing when preparing the space for improvised shelters.

3rd type of improvised shelters

This type of improvized shelters is located on higher floors of buildings and is suitable for the protection against the effects of industrial harmful agents heavier than the air and for the protection against poisonous substances, bacteriological (biological) means.

Industrial harmful agents heavier than the air are dangerous substances currently stored and used in industrial production.

In case of a sudden terrorist attack on chemical factories it is possible to use this type of protective shelters imminently for protection of population even without additional adjustments at least for a certain period of time until the intensity of the danger decreases (the decrease of the concentration on acceptable level) or until the evacuation of population from the affected area is organized.

CONCLUSION

The concept of population protection till 2013 with the prospect till 2020 in part 3.3 dealing with shelters, among others, says:

“For sheltering in case of extraordinary events with the danger of contamination by dangerous substances and effects of penetrating radiation, the citizens are recommended to use natural protective properties of constructions and make adjustments to prevent the penetration of theirs.

The municipalities will further have a decisive role during organization of sheltering of population and will, already in a calm period, cooperate with fire service of regions and select the facilities (e.g. underground garages, cellars) suitable for improvized sheltering of population."

When selecting buildings and facilities suitable for improvized sheltering of population it is necessary to take into consideration the above mentioned factors.

Generally the principle is that sheltering in a building is better than staying outside especially in the street between buildings.

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Literature

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