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Threats occurring in the functioning of shelter ventilation installations

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Abstract

Ventilation of facilities such as shelters is a very complex issue. First of all, such an object should be extremely tight so that intentional air pollution outside does not pose a threat to people inside. Secondly, the system must be characterized by high reliability, because for airtight objects the failure of the air conditioning system is also a threat to people inside. Thirdly, the system must provide microlimatic vacancies inside acceptable by people passing through the shelter - it is mainly about temperature and humidity.

Keywords: energy-efficient buildings, climate, multi-family shelter, ventilation systems

1 Introduction

In peacetime, each state prepares shelter facilities to protect the population from the effects of extraordinary threats, including with the physical and chemical state of the outside air. Shelters should provide:

- protection against primary and secondary effects of nuclear weapons, among others: shock wave hypertension and seismic nuclear explosion, effects of external fires, toxic industrial and other dangerous measures,
- protection against chemical and biological weapons,
- living conditions for people in a shelter.

Protective buildings or concealments are prepared in the basements of residential buildings, as well as by appropriate adaptation to perform a protective function: underground rooms, communication, commercial, storage service facilities, etc.

Shelter construction gained importance in Poland after 1989, i.e. since the emergence of a new political and military situation. Then the direct source of the conflict disappeared, resulting from system differences of different countries. A different system of international relations appeared that could pose a threat to the security of people's lives in a given country. This applies particularly to the possibility of industrial disasters, natural disasters and the threat of religious crises.

After the change of war doctrine, the role of any shelters providing shelter increased disproportionately. Civil Defense deals with this important issue. The need to maintain the required number of places in shelters, ensuring the survival of as many people as possible, is a basic task. In Polish conditions, it is not only the achievement of the 100% disguise indicator for residents that becomes a problem, but the maintenance of existing facilities in proper technical condition. Partial solution to the quantitative problem is the construction of bifunctional facilities. In this case, there is the possibility of peaceful, i.e. continuous use of the object for various purposes other than essential, with the possibility of their rapid adaptation to fulfill the basic protective function.

Shelters for Civil Defense can be divided into several basic types, due to their purpose and use:

- shelters for civilians - single-purpose facilities, designed to fulfill their basic task, awaiting to use,
- shelters for important or valuable material goods (e.g. art works, gold, supplies, etc.),
- bifunctional facilities that, in addition to the basic function of protecting people, other functions, warehouse, garage / parking, service point, basement in an apartment block, training room, youth club.

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Single-purpose shelter facilities are built with a specific purpose, e.g. to ensure concealment in advance of a selected group of people (workplaces, building residents, etc.).

While the tasks and operating conditions of single-purpose facilities are clearly and strictly defined, the purpose and use of dual-purpose facilities is much more complex. Due to the need to fulfill the basic function, the bifunctional shelter must have a well-thought-out functional arrangement and an appropriate structure. In advance, there should be separate rooms with full equipment for the implementation of the basic shelter function. These rooms should be excluded from room operation, keeping their equipment in full working order.

In the preparation of bifunctional objects for exploitation, time is of the essence. While tensions in international relations can be a signal to start adaptation work, giving more time for preparation, the abruptness of sudden, unpredictable phenomena deprives these objects of time needed for preparation, and thus limits or excludes their use in the basic function. For example, for an underground car park, forces and means to remove parked vehicles should be provided, means should be gathered and kept in full working order to prepare the object to perform the basic function, with the time calculated so that the object is ready for use before a real threat occurs.

The basic issue for creating adequate sanitary and hygienic comfort for people staying in a shelter is, apart from an efficient filtering system, proper equipment with sanitary equipment and accessories. [1–26]

2 The tightness of shelter constructions

In residential, public and other buildings, the air from the surrounding atmosphere freely penetrates inside. Also, air from inside the buildings easily escapes. The reason for this natural exchange of external and internal air in buildings is their construction and the properties of the materials used. These buildings have holes and gaps in the doors and windows, ceilings, etc. In addition, the materials used for their construction are porous and easily breathable.

Under the conditions of using toxic agents, contaminated air will also penetrate inside the buildings.

To obtain proper tightness of buildings intended for collective protection, it is necessary to completely isolate them from the external atmosphere. However, ensuring complete encapsulation of objects is practically impossible, because even with their exact sealing, there are always small gaps between individual structural elements and pores in building materials. Therefore, some air permeability is inevitable, even in specially sealed and secured facilities.

Contaminated air penetrates into closed and sealed rooms over time. Under certain conditions, a room may generate a concentration of poisonous substances above the permissible level, and then operation without the use of personal protective equipment is impossible.

The amount of contaminated air infiltrating the collective protection facility depends on two factors:

- air pressure difference on both sides of the wall (partition),
- size and shape of holes, gaps and pores.

The pressure difference on both sides of the partition can arise due to the following reasons:

- wind reaction on the structure,
- difference in air temperature inside and outside the room,
- shock wave pressure of a nuclear explosion,
- reduction of pressure inside the room, caused by the operation of exhaust ventilation

Encapsulation protects the inside of the shelter from the penetration from the outside of contaminants, infections and other dangerous agents as well as the spread of concentrations of chemical substances between the adopted cleanliness zones inside the shelter. The encapsulation of the shelter can be achieved by:

- making gas-tight external walls and gas-tight internal building partitions, between cleanliness zones,
- gas-tight closing of communication openings and other openings,
- maintenance during operation of a certain air pressure inside the shelter,
- providing the possibility of cutting off the shelter from the outside atmosphere and supplementing air losses to maintain the required overpressure (in the period when it is not taken from outside).

3 Shelter's ventilation systems

Mechanical ventilation system are used in shelters for:

- ensuring the required microclimate parameters for protected and working people, regardless of the condition and quality of the outside air,
- removal of harmful gases, heat vapors, etc.,
- supply of air for technological purposes, e.g. for combustion of generating sets, cooling in combustion engines, etc.,
- ensuring the encapsulation of the shelter by means of generating and maintaining air pressure, directing its flow outside the shelter in order to prevent penetration into its interior of contaminants and infections and other dangerous agents.

It is recommended to use outside air only for ventilation of clean zone rooms. Other rooms, in a conventionally clean and conventionally dirty zone, should be ventilated with secondary air. The ventilation air balance is prepared as follows:

- the amount of air necessary for ventilation of utility and sanitary rooms, combustion of the generating set in the engine, exfiltration through building partitions and other needs occurring in the planned shelter are determined.
- the air demand for people in the shelter is determined, depending on the nature of the activity, based on the applicable air standards per person,
- the amounts of air determined according to the above-mentioned points are compared, assuming a higher value for further calculations. This value determines the amount of air supplied to the shelter and forms the basis for the selection of ventilation devices.

The following mechanical ventilation systems can be carried out in shelters:

- central (main) supply ventilation system,
- central ventilation system for recirculation,
- central exhaust ventilation system,
- local ventilation systems (exhaust and recirculation),
- air regeneration system.

The distribution of air velocity in the occupied zone of protective structures depends on:

- air velocity in the supply air streams,
- crowding, especially from the influence of convection streams arising from the heat emitted by people,
- the temperature of the surfaces limiting the room and the wall streams arising near them,
- size and amount of furniture in the room (benches, bunks).

Experiments show that the temperature of the space-limiting surfaces in protective structures is almost equal to the temperature of the surrounding soil. In Polish conditions it is from 80C to several degrees and when filled with people it will significantly differ from the air temperature in the room. This condition will favor the formation of falling wall streams and condensation of moisture on the surface of the partitions.

Therefore, the basic task of ventilation systems used in protective constructions will be to maintain appropriate temperature, relative humidity and air velocity values in rooms, as well as to protect the surface of partitions against moisture condensation. Fluctuations of these parameters for physiological reasons are allowed only within strictly defined limits. The range of appropriate fluctuations in these parameters is an essential criterion for the degree of equipment of the installation with air treatment devices.

Over the past decades, the views of hygienists and doctors have changed both on the amount of air necessary for ventilation or air conditioning, as well as on the justification for this amount (from 8 to 32 m3 / h for a person). The life processes of the human body (breathing, sweating) and the need to ventilate the premises of protective buildings, when insulated with 100% recirculating air, have helped to solve this problem. Adopting 8 m3 standard for protective

objects within one hour for one person fresh air can be the basis for dimensioning ventilation or air-conditioning devices in protective buildings.

For the correct selection of the size and type of ventilation or air-conditioning installations used in a protective structure, the following issues of ventilation technique should be taken into account: the function and use of the protective structure, operational requirements of the installation, the amount of heat and moisture losses and gains, external and internal air pollution, microclimatic requirements, air distribution problems, required level of regulation of microclimate parameters, possibilities of obtaining heat and cooling energy. The correct solution of shelter filtration systems can only be achieved if the actual operating parameters of filtration or air conditioning installations are known.

Measurements of air efficiency in existing shelter filter ventilation systems help bring the operating parameters of the installation into compliance with the microclimate requirements of shelter rooms. In addition to appropriate air exchange, the ventilation system shapes the values of the supply air temperature so that, after compensating for the room's heat gains or losses, it provides a standard temperature value. In the case of air-conditioning installations, the scope of requirements in comparison with ventilation is extended by the following processes:

- keeping relative air humidity in the room,
- ensuring cleanliness of the supply air,
- ensuring air distribution appropriate to the needs.

4 Operational hazards

In the case of shelter buildings located in the underground of residential buildings, there is a very high threat to indoor air quality. These threats are caused by:

- shutting down the functioning of mechanical ventilation for economic reasons in shelter rooms not used in the peaceful period,
- lack of natural ventilation of shelter rooms (solved in a way enabling its quick blocking and sealing),
- high relative humidity of internal air accelerating the biological corrosion of building materials and the development of mold fungi,
- exhalation of radon from the walls and floor laid on the ground.

It should be emphasized that the use of such shelters to protect the population (in situations where contamination of the outside air is unlikely) can bring more harm than good.

Unused, sporadically ventilated and non-vacuumed rooms, as well as renovated, are a convenient environment for the development of mold fungi. If the relative humidity is exceeded by more than 65%, the mushrooms grow quickly and multiply. The air of enclosed and wet rooms is an ideal environment for the development of fungi. Even the air temperature close to 00C also does not limit their development.

Also, radon hazard is a kind of air pollution and cannot be omitted when analyzing the hygienic and health conditions of human stay in shelters located mostly in the basements of buildings. The greatest threat to the health of residents has α radiation from radon decay affecting the respiratory system. The most important sources of radon Rn-222 in indoor air are the natural radioactive elements Ra-226 and Ra-224 and the Th-228 track derivative. They are contained in the ground on which the building is founded and in building elements made of mineral resources (natural and waste).

The basic feature that distinguishes the heat exchange process in underground constructions from the analogous process in above-ground constructions is the impact of transient heat exchange conditions.

The transient thermal states in these buildings are caused by, among others by:

- variable heat gain load,
- transient heat conduction into the ground,
- transient heat accumulation in the building structure material and the surrounding ground,
- variable periods of work of defensive structures.

In defensive buildings, due to the requirements for the airtightness of the object, we have limited possibilities of adjusting all microclimatic parameters.

5 Conclusions

Ventilation and filtration systems in shelter facilities should be systematically improved. To specify the modernization directions for existing shelter and defense structures, it is advisable to conduct a number of technical audits. The technical parameters of devices and installations installed in tests and measurements help in determining the actual suitability of the shelter building. Two new investment directions, public and private, may appear in the area of new facilities. These directions should create one clear system of technical shelter infrastructure. The technical development of shelter construction and installation systems can occur through the development of simple in construction and at the same time reliable operation of air intake as well as protection of the interior of the building against sudden pressure or air overpressure. Such a set may include mineral bulk filters, double-acting explosion-proof valves and dual-drive fans (electric and human muscle power). Shelters should use ground heat to heat or cool the ventilation air supplied to the interior of the protective facility. New types of chemical filters should be used as well as typification of installation components and devices. Ventilation heat recovery devices, rational use of water, energy and waste should also be used in an environmentally friendly manner.

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