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Professional paper

Role of Ventilation-air Conditioning Systems in the Chemical, Biological, Radiological and Nuclear Terrorist Attack

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A B S T R A C T

The targets of terrorists are always areas where gathering or visiting a number of people. Such areas usually are equipped with air – ventilation systems that can become major inputs for contaminants, particularly chemical, biological, radiological and nuclear agents used in a terrorist attack. In order to prevent a terrorist act is necessary to implement certain security measures: preventing access to the suction opening, preventing access to the engine room and the roof of the building, the implementation of other measures of security – cameras, alarms, sensors and other detection and prevention of the spread of technical information. However, if you come to the entry of certain harmful agents into the building, properly designed, installed and maintained ventilation – air conditioning systems can significantly reduce the effects of chemical, biological, radiological and nuclear agents released either inside or outside the building. Due to the different properties of chemical agents effective mechanisms of filtration in air conditioning ventilation system is very different. Biological agents are removed by filtration while to successfully prevent the entry of radioactive aerosols in the facilities necessary to use HEPA filters to the decontamination of the entire ventilation system. It can be concluded that the systems for filtration and air purification can protect the building and the people in it from the effects of chemical, biological, radiological and nuclear attacks, although it is impossible to completely eliminate risk.

***Key words**: air-ventilation systems, terrorist attack, chemical, biological radiological and nuclear agents*

Introduction

In order to create panic among the population, the target of terrorists are always a gathering place or visiting a number of citizens such as office buildings, schools, hospitals, sports facilities, etc. These objects are usually equipped with central air-ventilation systems which are designed in such way that air circulates all areas, thus becoming the main entrance and distribution systems for contaminants including chemical, biological, radiological and nuclear (CBRN) agents. In order to prevent the terrorist act, it is necessary to implement certain security measures:

– Prevent access to the intake ports by establishing safety zone, which is one of the most important steps in protecting air spaces (indoor air). The intake ports are usually located on the outside of the building that allows terrorists introduction of chemical, biological, radiological and nuclear agents to their distribution within the building. But if located high on the facade of the building it prevents unauthorized access (Figure 1).

– Prevent unauthorized persons access to the engine room where there is a central mechanical system, very suitable for the input of contaminants. So access to this part of the heating and cooling-ventilation system must be strictly controlled.

– Prevent unauthorized persons from gaining access to the roof of the building which are also open ventilation system and other equipment. Therefore, the roof of the building should be strictly controlled.

– Implement other security measures such as security guards, alarms, cameras, detection sensors, etc.

– Physically isolate the lobby, the room where the receiving post office, warehouse and garage from the rest of the building because these are places where chemical, bi-

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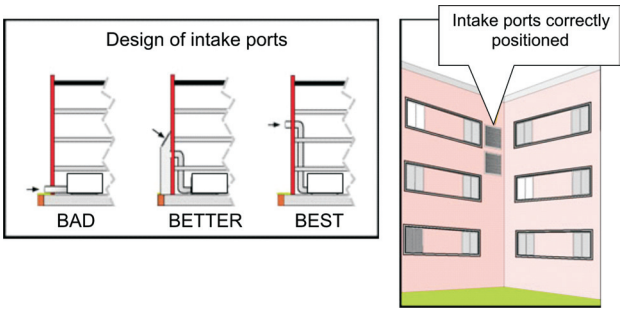

Fig. 1. Methods of setting the intake ports on the facade. Source: NIOSH.

ological, radiological and nuclear agents can easily be entered into the building.

– Prevent the dissemination of technical information on the mechanical and electrical installations, security measures, plans and schemes and standard operating procedures of evacuation in emergency situations[1–3].

If an entry of certain harmful agents into the building is properly designed, installed and maintained, ventilation – air conditioning systems can significantly reduce the effects of chemical, biological, radiological and nuclear agents released either inside or outside the building. To achieve this goal it is necessary to know the following:

1. What kind of system for filtering and purifying the air is most effective for removing (CBRN) agents,

2. Which type of system for filtering and purifying the air can be implemented in the existing system, and that would improve the efficiency,

3. What type of filtration and air purification installed to replaced the existing outdated system,

4. In what way properly maintain filtering and purification systems[2,4,6].

Pollutants in the air in different forms (gas, vapor and aerosol in the form of solid and liquid particles). Therefore, it is important to know that the filtration systems relating to the removal of agents in aerosol form, and purification systems using sorbent remove gaseous pollutants from the air, but not the aerosol. Aerosol is collected on filters that are more efficient as they pores less. Despite all the knowledge of the major problems are:

1. Unsatisfactory adhesion to the filter frames leading to the passage of air through the cracks. Such air remains unfiltered, resulting in lack of efficiency filtration,

2. High price – quality heating and cooling ventilation system which provides the initial installation, modification, operation and maintenance,

3. Porosity building materials facility[7,8].

As well as other pollutants, chemical, biological, radiological and nuclear agents spread by air in gaseous form or as an aerosol with a note that the chemical agents with relatively high vapor pressure of gas, while others may be in other forms. Biological and radiological agents are usually aerosols with a wide range of particle sizes.

Filtration of particles from the air

Filtration of particles carried by a filter that can be mechanical or electrostatic (enhancing filtration). Both types of filters are made from fibrous materials (cotton, fiberglass, polyester, polypropylene, etc.) with good properties for the removal of particles from the air, including biological agents in the air (Figure 2).

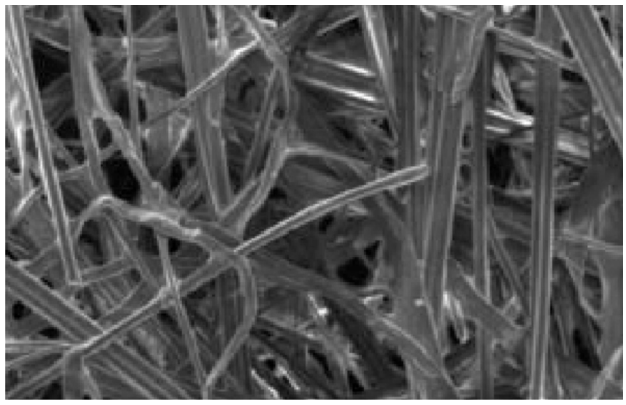

Fig. 2. Polyester-glass fibrous filter (SEM image).

Purification of gases from the air

The gases from the air are purified using sorbents used for mechanical adsorption and chemisorption. Sorbent are made of porous materials (various clays, carbon or polymer complex). Because of sorbent requires almost completely eliminate gases and vapors from the air, it is necessary to highlight some of the important parameters that may prevent a successful air purification:

1. Dielectric concentration: concentration of contaminants from the output above that the sorbent does not work fully,

2. Breakthrough time: the time elapsed between the initial contact and the concentration of toxic agents from the input side of sorbent and concentration on its output side,

3. Concentration of toxic agents in the air before entering the sorbent,

4. Residence time: the time of contact with the toxic agents in sorbent,

5. Transfer Zone mass or critical depth: refers to the thickness of the adsorbent that is required to effectively eliminate or reduce the concentration of toxic gas or vapor.

Recommendations

Before choosing a strategy of filtration and purification of air that must be considered a potential terrorist

TABLE 1
FILTRATION MECHANISMS OF VARIOUS CHEMICAL AGENTS IN THE AIR-VENTILATION SYSTEMS

Agent	Filtration mechanism
Nerve	Strong physical adsorption of the slow hydrolysis of adsorbed agents
Mustard agent	
Phosgene (asphyxiant)	Poor physical adsorption with the degradation on the impregnants. Hydrolysis of phosgene created hydrochloride and carbon dioxide. Hydrochloride reacts with copper and zinc carbonate (impregnants) and the resulting copper and zinc chlorides.
Cyanogen chloride (blood agent)	Poor physical adsorption with the degradation of the impregnants. Cyanogen chloride is subjected to hydrolysis to triethylenediamine. After that follows degradation of acid products (hydrogen chloride and cyanogen acid) with copper and zinc carbonate. Cyanogen acid hydrolyzed to carbon dioxide and ammonia.
Hydrogen cyanide (blood agent)	Poor physical adsorption with the degradation on the impregnants. Hydrogen cyanide reacts with copper (+2) and zinc carbonate producing copper (+2) and zinc cyanide. Copper (+2) cyanide is converted to copper cyanide and cyanogen. Cyanogen reacts with ammonium dimolybdate creating oxamide which is very strongly adsorbed on activated carbon.
Arsine (blood agent)	Poor physical adsorption with the degradation on the impregnants. In conditions of low humidity, arsine is oxidized with copper (+2) in the form of arsenic trioxide and arsenic pentoxide. In conditions of high relative humidity arsine is oxidized with silver impregnant in the form of arsenic oxide.

threat, we need answered by professionals on a few issues that directly affect the efficiency of removal of chemical, biological, radiological and agents in the air. These agents are extremely toxic and the type of air conditioning system depends on the efficiency of their elimination from the air. Many factors can influence the effect of these substances on human health. Its toxicity, physical and chemical properties, concentration, wind direction, location layoffs and other vital part is evaluation of the complete heating and cooling – ventilation system, and large buildings evaluation must include fewer ventilation units that are part of the whole system. Answers to the questions significantly affect decision making in selecting types of filters and/or sorbents, their efficiency and maintenance processes of the system. Some important questions include:

1. Are the contaminants in the form of particles, gas or both toxic and to which group they belong – toxic industrial or military agents?

2. In what way these substances can enter the building? Are discharged inside or outside the building?

3. What is expected from the ventilation system? Filtering or purifying air? How to achieve the desired quality of the air in the room?

4. How is made the entire system? Is there any air leaks around the filtration units (quality seal)?

5. Does it include only maintenance or cleaning and decontamination of the entire system?

Elimination of chemical agents mechanisms of filtration and adsorption

The effects of chemical, biological and radiological agents are very different. Classical chemical weapons (gas or aerosol) includes a variety of compounds that people act in different ways. A number of mustard agent or contact poisons and nerve agents have small evaporating pressure and the air transport as a liquid aerosol, while those with high pressure vapor transfer in a gaseous state. Blood poisons (cyanide, cyanogen chloride, arsine) and asphyxiant (phosgene, diphosgene) are very volatile inhaled toxins. Furthermore, nerve agents, organophosphate ester derivatives (VX, tabun, soman and sarin) are poisonous ever synthesized compounds up to 100 times more toxic than the above, and some very volatile. Due to the different properties of chemical agents effective mechanisms of filtration in air conditioning ventilation system is very different[9,10] (Table 1).

Elimination of biological agents and toxins mechanisms of filtration and adsorption

Biological agents such as *Bacillus anthracis* – anthrax agent, *Variola major* – smallpox, *Yersinia pestis* – bubonic plague, *Brucella suis* – brucellosis, *Francisella tularensis* – tularemia, *Coxiella burnetii* – Q fever, *Clostridium botulinum* – botulism, cause viral hemorrhagic fevers and other, are potentially biological weapons in terrorist attacks. Each of these biological agents can be spread by air as an aerosol, and their characteristics such as particle size, infectivity, toxicity, stability of aerosol concentration increase the risk of mass infection. Other factors are the transmission of infection from person to person and difficult treatment. Biological agents have many routes of entry into the body, as well as a number of physiological effects, and are removed by filtration using different types of filters.

Toxins category belong bacterial toxins (exotoxins and endotoxins), algal (blue-green algae and dinoflagellates), mycotoxins (trichothecenes and aflatoxins), botulin and other toxins enter the body by ingestion, inhalation,

and the most effective in the form of aerosols. In the ventilation systems they removed by filtration[11].

Elimination of radiological agents

Radiological agents appear in three forms: alpha, beta and gamma radiation, which is emitted by radioisotopes in aerosols, related to particulate matter in the gaseous state. There are three primary scenarios under which radioactive materials can be released in a terrorist attack:

1. Conventional explosives (dirty bomb),
2. Attack on nuclear facilities,
3. Nuclear weapons.

In all three cases, the normal filtration is not efficient enough. To successfully prevent the entry of radioactive aerosols in buildings must use HEPA filters, with the decontamination of the entire ventilation system[12].

Conclusion

Filtration systems and air purifiers can protect the building and the people in it from the effects of chemical, biological and radiological attacks, although it is impossible to completely eliminate risk. Some systems meet strict criteria, some in need of an upgrade. Chemical, biological and radiological agents can be effectively removed from the air unit or they prevent entry into the premises, provided that the systems for filtration and air purification properly designed, installed and properly maintained. Such systems improve air quality in the premises at all times, which reduces respiratory infections, irritation of the mucous membranes of the eye, nose and throat, headaches, difficulty concentrating, fatigue and the appearance of symptoms of asthma and allergies in people who reside in these areas.

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ULOGA VENTILACIJSKO-KLIMATIZACIJSKIH SUSTAVA U KEMIJSKOM, BIOLOŠKOM, RADIOLOŠKOM I NUKLEARNOM TERORISTIČKOM NAPADU

SAŽETAK

Mete terorista uvijek su prostori gdje se okuplja ili boravi veći broj ljudi. Takvi prostori uobičajeno su opremljeni klimatizacijsko-ventilacijskim sustavima koji mogu postati glavni ulazi za kontaminirajuće tvari, a posebice kemijske, biološke i radiološke agense upotrebljene u terorističkom napadu. U svrhu spriječavanja terorističnog čina potrebno je provoditi određene sigurnosne mjere: spriječavanje pristupa usisnim otvorima, spriječavanje pristupa strojarnicama i krovu zgrade, implementiranje drugih mjera sigurnosti – kamere, alarmi, detekcijski senzori i dr. te spriječavanje širenja tehničkih informacija. Ako ipak dođe do unosa određenih štetnih agenasa u zgradu, ispravno dizajnirani, instalirani i održavani ventilacijsko-klimatizacijski sustavi mogu bitno smanjiti učinke kemijskih, bioloških i radioloških agenasa ispuštenih bilo unutar ili izvan zgrade. Zbog različitih svojstava kemijskih agenasa mehanizmi učinkovite filtracije u klimatizacijsko ventilacijskim-sustavima se vrlo razlikuju. Biološki agensi odstranjuju se filtracijom dok je za uspješno spriječavanje ulaska radioaktivnog aerosola u objekte potrebno upotrijebiti HEPA filtere uz dekontaminaciju cijelog ventilacijskog sustava. Može se zaključiti da sustavi za filtraciju i pročišćavanje zraka mogu zaštititi zgradu i osobe u njoj od učinaka kemijskog, biološkog i radiološkog napada, iako je nemoguće potpuno eliminirati rizik.