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Editorial

Protecting Buildings from Chemical and Biological Warfare Agent Attacks – a long journey

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The terrorist attacks on New York City and Washington D.C. on September 11, 2001 and the subsequent anthrax distribution by mail have spawned concerns about various possible forms of terrorism, including airborne/aerosolized chemical and biological warfare agent (CBWA) attacks in a building. Several CBWA that could be used as weapons of terror are of particular concern. For example, biological pathogens are attractive to a determined enemy because they are inexpensive to produce, can be manufactured quickly in large quantities, and are relatively easy to deliver. Modern molecular biology methods can give a cell surface features that no human immune system has ever seen before. This ability to engineer a new cell surface also means that current antibody-based sensors can also be easily evaded, and even individuals who have been immunized against known forms of a pathogen could be susceptible to an attack. Other examples of biological agents include bacterial pathogens that have inbred resistance to all known antibiotics, and engineered viruses that bypass all known vaccines. Should these prominent biological agents be used by terrorists, the consequence would be devastating. An attack by chemical agents, such as modern nerve-gas chemical agents, is not less severe than biological agents, because they can easily pass right through ordinary filters of building HVAC systems.

In May 2002, the National Institute for Occupational Safety and Health released guidelines for protecting ventilation systems in commercial and government buildings from chemical, biological and radiological attack (NIOSH Publication No. 2002-139). The document offers recommendations on physical security, ventilation, filtration, maintenance, administration, and training. ASHRAE is also very active regarding the issue of building security. The ASHRAE Presidential Ad Hoc Committee on Homeland Security produced a report in January 2003 entitled: "Risk Management Guidance for Health, Safety and Environmental Security under Extraordinary Incidents". On April 14, 2004, ASHRAE sponsored a satellite broadcast on building security to discuss risk management, HVAC and refrigeration systems, ventilation and pressurization, filtration and air cleaning, and personal protection. Although it is still challenging to protect a building against a possible CBWA attack, several steps can be undertaken to assess and reduce building vulnerability, undertake pre-event planning, and prepare for actions to take during an attack. There are pointers that provide ready information on how to assess the vulnerability of a building to CBWA threats, what low-cost and medium-cost actions to take to reduce such vulnerability, etc. A compendium of good quality relevant websites for protecting buildings from CBWA threats, including the ASHRAE guidance and many others as well, can be found at: <http://securebuildings.lbl.gov/links.html>

For ASHRAE engineers, some of the technologies used to protect buildings from CBWA attacks may be similar to those used to improve indoor air quality or control the spread of smoke within a building during a fire. Some others will be quite different. A few parts per million (ppm) of smoke in the building air may be acceptable, since it does not impair visibility nor cause asphyxiation. However, exposure for a few minutes to a few ppm of a nerve-agent is commonly fatal. A major difference between a CBWA attack and an indoor air quality problem is the extremely high toxicity of the contaminant, and therefore extremely low levels of acceptable concentration, in the former scenario. Furthermore, within the world of CBWA threats, one needs to sharply distinguish between the responses

to chemical attack and a biological attack. Under a chemical attack, the health threat to the exposed individuals is immediate, and a rapid response is essential to save lives. In a biological attack, the health threat (disease) is *not* immediate, and could be treated with appropriate medication. However, the worst outcome of a biological attack on a building would be release of a disastrous epidemic, and this must be prevented by diligent quarantine and medical treatment of all possibly exposed personnel. This of course assumes that the biological agent release is detected and identified so proper medical measures can be taken.

ASHRAE engineers may use filters and ultraviolet (UV) lamps to remove a variety of biological agents. These measures are not relevant to contain a chemical threat. Furthermore, for a biological threat, filters and UV lamps will usually not suffice to contain the spread of the biological agent from tracking, resuspension, and direct inter-zonal transport. To successfully address indoor air quality problems, we often need to know contaminant source locations and strengths. Similarly, to contain or reduce exposures in the case of a CBWA attack, it is crucial to know when, where, what, and how a CBWA is released. Without such information, it is difficult, if not impossible, to have effective measures to protect building occupants. To improve indoor air quality, we often use more outdoor air because it is fresher. For a CBWA attack, the air from the intake can be better or worse depending on whether a release occurred indoors or outdoors.

Sensors and sensor systems are crucial for obtaining the necessary information. As an HVAC engineer, the most familiar sensors are probably those for temperature, humidity, and carbon dioxide. These sensors are generally inexpensive, quick to respond, and compact. Unfortunately, most chemical and biological sensors are expensive, slow to respond, and bulky. A biological sensor can easily cost tens of thousand dollars. In many cases, one has to wait for hours, if not days, to confirm the existence of a specific biological agent. Some sensors or sensing systems can barely fit into a small truck. In general, the current bio-threat sensing technologies are too expensive, too bulky, and too slow to provide vital information for building protection. Sensing technologies for chemical agents are much more mature, though still quite expensive. Agent-specific fast sensors for chemical threats are on the horizon for use in buildings.

Obviously one could not afford to place such sensors or sensor systems everywhere in most buildings. It is important to use limited information available from the sensors to predict how CBWA would be transported and distributed in buildings. Computational fluid dynamics, multi-zone models, and zonal models are available methods. However, accurate methods need too much computing time, and fast ones are not accurate. A reliable and fast method has yet to be developed for the prediction of CBWA dispersion in and around buildings. It may be possible to develop an interior airflow model and to pre-calculate an exterior airflow database for a specific building under study, and then rapidly exercise it to get "good enough" results for guidance to protect the building in real time when under attack. This is an active area of current research.

Only after we know how CBWA is dispersed in a building could HVAC systems play a vital role in creating a safe environment for building occupants, temporarily sheltering them or aiding in evacuation. The systems would work differently if the CBWA release is indoors instead of outdoors. Since air travels through ducts at a very high speed, fast reaction of the HVAC system is essential. A few seconds delay in shutting down the fan in the HVAC systems could make the situation much worse. Furthermore, airflow through the HVAC systems in a building is commonly not well balanced, and many of us leave doors open when we work. The unbalanced airflow and the airflow caused by different air temperature settings in two adjacent rooms would lead to cross contamination. Effective control of

airflow in buildings needs to be developed. One may argue that we can use individual air conditioners and shut doors all the time. It would then be hard to pressurize the building and to prevent infiltration in case of an outdoor CBWA release. Surely, the protection of buildings from CBWA attacks needs an overhaul of the HVAC design paradigm.

While preparing this editorial, the fire alarm in my office building sounded. Since I did not feel any heat nor see dark smoke, I stayed a minute longer to finish the last paragraph. When I left my room, many of my colleagues were still in their offices. It was fortunate that the fire alarm was a false one. In the future, should we have several false alarms for CBWA in my building, I wonder whether I would leave the building if I did not see or smell anything. Unfortunately, most biological agents are colorless and odorless, as are many chemical nerve-agents.