



Protecting Building Environments from Airborne Chemical, Biological, or Radiological Attacks

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Case Studies

Protecting Building Environments from Airborne Chemical, Biological, or Radiological Attacks

Dawn Tharr, Column Editor

Reported by Kenneth R. Mead and Michael G. Gressel

This document identifies actions that a building owner or manager can implement without undue delay to enhance occupant protection from an airborne chemical, biological, or radiological (CBR) attack. The intended audience includes building owners, managers, and maintenance personnel of public, private, and governmental buildings, including offices, laboratories, hospitals, retail facilities, schools, transportation terminals, and public venues (e.g., sports arenas, malls, coliseums). This document is not intended to address single-family or low-occupancy residential housing (less than five family units). Higher-risk facilities such as industrial facilities, military facilities, subway systems, and law enforcement facilities require special considerations that are beyond the scope of this guide.

The likelihood of a specific building being targeted for terrorist activity is generally difficult to predict. As such, there is no specific formula that will determine a certain building's level of risk. Building owners must make their own decisions regarding how to reduce their buildings' vulnerability to CBR attacks. These decisions may be aided by a comprehensive building security assessment; many government and private organizations have identified resources that provide insight into building security assessments. The reference list in the Appendix will help the reader obtain this information.

No building can be fully protected from a determined individual who is intent on releasing a CBR agent. The recommendations in this guide will not preclude injuries or fatalities in the event of a CBR release. However, facility owners and managers can transform their buildings into less attractive targets by increasing the difficulty of introducing a CBR agent, by increasing the ability to detect terrorists before they carry out an intended release, and by incorporating plans and procedures to mitigate the effects of a CBR release. Some of the references listed at the end of this document provide information on how to recognize if a CBR release has occurred. These recommendations focus on airborne releases of CBR agents¹ in quantities capable of being easily transported by a few individuals. Protection from other types of attacks such as explosions, building collapses, and water supply contamination, requires much different measures, which are not addressed in this document.

The recommendations set forth in this document are not intended to be a minimum requirement that every building owner and manager should implement for every building. Rather, decisions concerning which protective measures ought to be implemented for any building should be based on several factors, including the perceived risk associated with the building and its tenants, engineering and architectural feasibility, and cost.

Background

Terrorism events have increased interest in the vulnerability of U.S. work-

places, schools, and other occupied buildings to CBR threats. Of particular concern are the air flow patterns and dynamics in buildings, specifically in their heating, ventilating, and air-conditioning (HVAC) systems. These systems can become an entry point and a distribution system for hazardous contaminants, particularly CBR agents. Building owners need reliable information about how they can (1) modify their buildings to decrease the likelihood or effects of a CBR incident and (2) respond quickly and appropriately should a CBR incident occur. Comprehensive guidance is needed in several areas, including the following:

- How to modify existing buildings for better air protection and security
- How to design new buildings to be more secure
- What plans building managers should prepare in advance to help them make effective decisions in the midst of a CBR incident

Preparatory Recommendation— Know Your Building

While more comprehensive guidance is being developed, this document focuses on the shorter-term goals of identifying those protective actions that you can take immediately. It recognizes, however, that some recommendations may not be feasible for you or in all situations.

An important first step in initiating any plan to modify building system design or operation is to understand these systems. Ask yourself questions such as,

¹References to a release of a CBR agent in this document will always refer to an airborne CBR release.

“How were they intended to operate?” and “How do they currently operate?”

Getting to know your building may be best handled by conducting a walk-through inspection of the building and its systems, including the HVAC, fire protection, and life-safety systems. During this inspection, compare the most up-to-date design drawings available to the operation of the current systems.² This step may require, or benefit from, the assistance of qualified outside professionals. Without this baseline knowledge, it is difficult to accurately identify what impact a particular security modification may have on building operation. While it is important to understand how the existing building systems function, the systems need not operate per design before you implement security measures. A partial list of items to consider during your building walk-through includes the following:

- What is the mechanical condition of the equipment?
- What filtration systems are in place? What are their efficiencies?
- Is all equipment appropriately connected and controlled? Are equipment access doors and panels in place and appropriately sealed?
- Are all dampers (outdoor air, return air, bypass, fire, and smoke) functioning? Check to see how well they seal when closed.
- How does the HVAC system respond to manual fire alarm, fire detection, or fire-suppression device activation?
- Are all supply and return ducts completely connected to their grilles and registers?
- Are the variable air volume (VAV) boxes functioning?
- How is the HVAC system controlled? How quickly does it respond?

- How is the building zoned? Where are the air handlers for each zone? Is the system designed for smoke control?
- How does air flow through the building? What are the pressure relationships between zones? Which building entryways are positively or negatively pressurized? Is the building connected to other buildings by tunnels or passageways?
- Are utility chases and penetrations, elevator shafts, and fire stairs significant air flow pathways?
- Is there obvious air infiltration? Is it localized?
- Does the system provide adequate ventilation given the building’s current occupancy and functions?
- Where are the outdoor air louvers? Are they easily observable? Are they or other mechanical equipment accessible to the public?
- Do adjacent structures or landscaping allow access to the building roof?

Specific Recommendations

The recommendations can be divided into four general categories: (1) things not to do; (2) physical security; (3) ventilation and filtration; and (4) maintenance, administration, and training. Some of these items, such as securing mechanical rooms, may be started prior to your completing the recommendations in the Know Your Building section. Items within each of the four categories are listed in the order of priority. Items considered to be highly critical are identified by a bold-faced number. As you review these recommendations, consider their potential implications on the contract language necessary for existing and future service contracts. A brief discussion of the four categories and some

commonly considered recommendations follow.

Things Not to Do

More than anything else, building owners and managers should ensure that any actions they take do not have a detrimental effect on the building systems (HVAC, fire protection, life-safety, etc.) or the building occupants under normal building operation. Some efforts to protect a building from a CBR attack could have adverse effects on the building’s indoor environmental quality. Building owners and managers should understand how the building systems operate and assess the impact of security measures on those systems.

1. *Do not permanently seal outdoor air intakes.* Buildings require a steady supply of outdoor air appropriate to their occupancy and function. This supply should be maintained during normal building operations. Closing off the outdoor air supply vents will adversely affect the building occupants and likely result in a decrease in indoor environmental quality (and an increase in indoor environmental quality complaints).
2. *Do not modify the HVAC system without first understanding the effects on the building systems or occupants.* This caution directly relates to the recommendation that building owners and managers should understand the operation of their building systems. If there is uncertainty about the effects of a proposed modification, a qualified professional should be consulted.
3. *Do not interfere with fire protection and life-safety systems.* These systems provide protection in the event of fire or other types of emergencies. They should not be altered without guidance from a

²If sufficient questions or surprises arise from the building walk-through, an independent evaluation by a qualified HVAC professional should be used to establish a useful baseline.

professional specifically qualified in fire protection and life-safety systems.

Physical Security

Preventing terrorist access to a targeted facility requires physical security of entry, storage, roof, and mechanical areas, as well as securing access to the outdoor air intakes of the building's HVAC system. The physical security needs of each building should be assessed, as the threat of a CBR attack will vary considerably from building to building. For example, the threat to a large corporate headquarters may be considered greater than the threat to a small retail establishment. Some physical security measures, such as locking doors to mechanical rooms, are low-cost and will not inconvenience the users of the building. These types of measures can be implemented in most buildings. Other physical security measures, such as increased security personnel or package x-ray equipment, are more costly and may inconvenience users substantially. These measures should be implemented when merited after consideration of the threat and consequences of a terrorist attack. Building owners and managers should be familiar with their buildings and should understand what assets require protection, as well as what characteristics about the building or its occupants make it a potential target. By first assessing the vulnerabilities of facilities, building owners and managers can address physical security in an effective manner. While the identification and resolution of building vulnerabilities will be specific to each building, some physical security actions are applicable to many building types. These include the following:

1. *Prevent access to outdoor air intakes.* One of the most important steps in protecting a building's indoor environment is the security of the outdoor air intakes. Outdoor air enters the building through these intakes and is distributed throughout the building by the HVAC system. Introducing CBR agents into

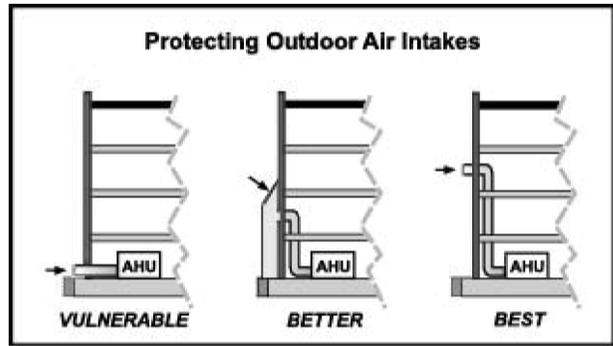


FIGURE 1

Secure outdoor air intake.

the outdoor air intakes allows a terrorist to use the HVAC system as a means of dispersing the agent throughout a building. Publicly accessible outdoor air intakes located at or below ground level are at greatest risk—due partly to their accessibility (which also makes visual or audible identification easier) and partly because most CBR agent releases near a building will be close to the ground and may remain there. Securing the outdoor air intakes is a critical line of defense in limiting an external CBR attack on a building (see Figure 1).

- *Relocate outdoor air intake vents.* Relocating accessible air intakes to a publicly inaccessible location is preferable. Ideally, the intake should be located on a secure roof or high side wall (see Figure 2). The lowest edge of the outdoor air intakes should be placed at the highest feasible level above the ground or above any nearby accessible level (i.e., adjacent retaining walls, loading docks, handrail). These measures are also beneficial in limiting the inadvertent introduction of other types of contaminants, such as landscaping chemicals, into the building.
- *Extend outdoor air intakes.* If relocation of outdoor air

intakes is not feasible, intake extensions can be constructed without creating adverse effects on HVAC performance. Depending on budget, time, or the perceived threat, the intake extensions may be temporary or constructed in a permanent, architecturally compatible design. The goal is to minimize public accessibility. In general, this means the higher the extensions, the better—as long as other design constraints (excessive pressure loss, dynamic and static loads on structure) are appropriately

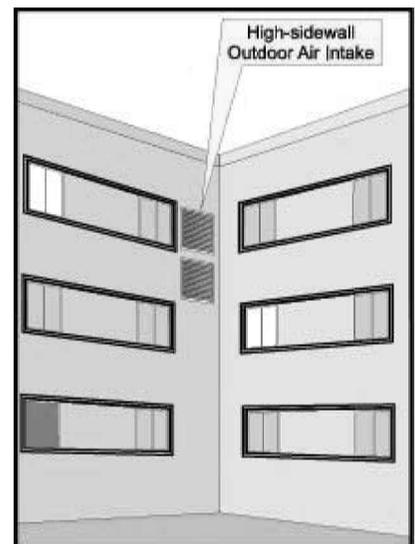


FIGURE 2

Relocate outdoor air intake vents.

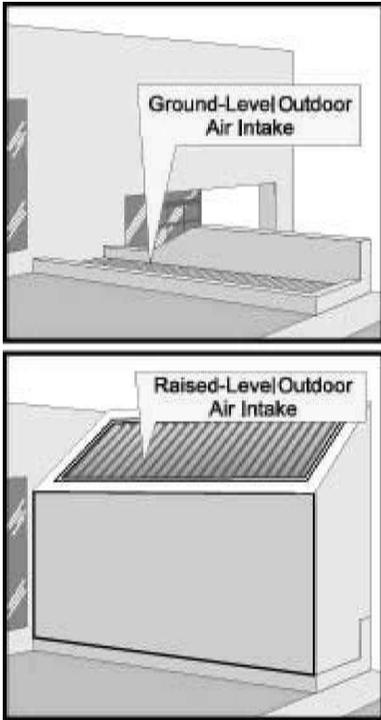


FIGURE 3

Extend outdoor air intake.

considered. An extension height of 12 feet (3.7 m) will place the intake out of reach of individuals without some assistance (see Figure 3). Also, the entrance to the intake should be covered with a sloped metal mesh to reduce the threat of objects being tossed into the intake. A minimum slope of 45° is generally adequate (see Figure 4). Extension height should be increased where existing platforms or building features (i.e., loading docks, retaining walls) might provide access to the outdoor air intakes.

- *Establish a security zone around outdoor air intakes.* Physically inaccessible outdoor air intakes are the preferred protection strategy. When outdoor air intakes are publicly accessible, and relocation or physical extensions are not viable options,

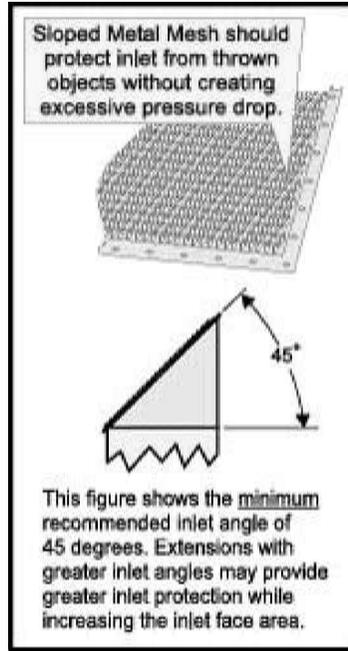


FIGURE 4

Cover intakes with sloped metal mesh.

perimeter barriers that prevent public access to outdoor air intake areas may be an effective alternative. Iron fencing or similar see-through barriers that will not obscure visual detection of terrorist activities or a deposited CBR source are preferred (see Figure 5). The restricted area should also include an open buffer zone between the public areas and the intake louvers. Thus, individuals attempting to enter these protected areas will be more conspicuous to security personnel and the public. Monitoring the buffer zone by physical security, closed-circuit television (CCTV), security lighting, or intrusion detection sensors will enhance this protective approach.

2. *Prevent public access to mechanical areas.* Closely related to the relocation of outdoor air intakes is

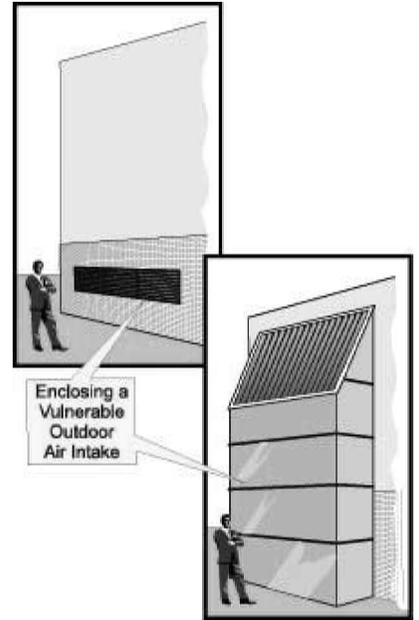


FIGURE 5

Provide a secure zone around air intakes.

the security of building mechanical areas. Mechanical areas may exist at one or more locations within a building. These areas provide access to centralized mechanical systems (HVAC, elevator, water, etc.), including filters, air handling units, and exhaust systems. Such equipment is susceptible to tampering and may subsequently be used in a CBR attack. Access to mechanical areas should be strictly controlled by keyed locks, keycards, or similar security measures. Additional controls for access to keys, keycards, and key codes should be strictly maintained.

3. *Prevent public access to building roofs.* Access to a building's roof can allow ingress to the building and access to air intakes and HVAC equipment (e.g., self-contained HVAC units, laboratory or bathroom exhausts) located on the roof. From a physical security perspective, roofs are like other entrances to the building and should be secured appropriately. Roofs with HVAC equipment should be

treated like mechanical areas. Fencing or other barriers should restrict access from adjacent roofs. Access to roofs should be strictly controlled through keyed locks, key-cards, or similar measures. Fire and life-safety egress should be carefully reviewed when restricting roof access.

4. *Implement security measures such as guards, alarms, and cameras to protect vulnerable areas.* Difficult-to-reach outdoor air intakes and mechanical rooms alone may not stop a sufficiently determined terrorist. Security personnel, barriers that deter loitering, intrusion detection sensors, and observation cameras can further increase protection by quickly alerting personnel to security breaches near the outdoor air intakes or other vulnerable locations.
5. *Isolate lobbies, mailrooms, loading docks, and storage areas.* Lobbies, mailrooms (including various mail processing areas), loading docks, and other entry and storage areas should be physically isolated from the rest of the building. These are areas where bulk quantities of CBR agents are likely to enter a building. Building doors, including vestibule and loading dock doors, should remain closed when not in use.

To prevent widespread dispersion of a contaminant released within lobbies, mailrooms, and loading docks, their HVAC systems should be isolated, and the areas should be maintained at a negative pressure relative to the rest of the building, but at positive pressure relative to the outdoors. Physical isolation of these areas (well-sealed floor-to-roof-deck walls, sealed wall penetrations) is critical to maintaining the pressure differential and requires special attention to ensure airtight boundaries between these areas and adjacent spaces. In some building designs (e.g., those having lobbies with elevator access), establishing a negative pressure differential will

present a challenge. A qualified HVAC professional can assist in determining whether the recommended isolation is feasible for a given building. In addition, lobbies, mailrooms, and loading docks should not share a return-air system or return pathway (e.g., ceiling plenum) with other areas of the building. Some of these measures are more feasible for new construction or buildings undergoing major renovation.

Building access from lobby areas should be limited by security checks of individuals and packages prior to their entry into secure areas. Lobby isolation is particularly critical in buildings where the main lobbies are open to the public. Similar checks of incoming mail should also occur before its conveyance into the secure building areas. Side entry doors that circumvent established security checkpoints should be strictly controlled.

6. *Secure return-air grilles.* Similar to the outdoor air intakes, HVAC return-air grilles that are publicly accessible and not easily observed by security may be vulnerable targets for CBR contaminants. Public access facilities may be the most vulnerable to this type of CBR attack. A building-security assessment can help determine which, if any, protective measures to employ to secure return-air grilles. Take caution that a selected measure does not adversely affect the performance of the building HVAC system. Some return-air grille protective measures include (1) relocating return-air grilles to inaccessible yet observable locations, (2) increasing security presence (human or CCTV) near vulnerable return-air grilles, (3) directing public access away from return-air grilles, and (4) removing furniture and visual obstructions from areas near return-air grilles.
7. *Restrict access to building operation systems by outside personnel.*

To deter tampering by outside maintenance personnel, a building staff member should escort these individuals throughout their service visit and should visually inspect their work before final acceptance of the service. Alternatively, building owners and managers can ensure the reliability of prescreened service personnel from a trusted contractor.

8. *Restrict access to building information.* Information on building operations—including mechanical, electrical, vertical transport, fire and life-safety, security system plans and schematics, and emergency operations procedures—should be strictly controlled. Such information should be released to authorized personnel only, preferably by the development of an access list and controlled copy numbering.
9. *General building physical security upgrades.* In addition to the security measures for HVAC and other building operations described earlier, physical security upgrades can enhance the overall security of a building. A building or building complex might have security fencing and controlled access points. Some buildings such as museums are, by their very nature, openly accessible to the public. However, even in these buildings, areas such as mechanical rooms need to remain off-limits to unauthorized individuals. Unless the building is regarded as open to the general public, owners and managers should consider not allowing visitors outside the lobby area without an escort. Layered levels of security access should be considered. For example, entry to a hospital's patient care areas could be less strict than to hospital laboratories, and successively more strict for other areas, such as ventilation control rooms. Physical security is of prime concern in lobby areas.

Ventilation and Filtration

HVAC systems and their components should be evaluated with respect to how they impact vulnerability to the introduction of CBR agents. Relevant issues include the HVAC system controls, the ability of the HVAC system to purge the building, the efficiency of installed filters, the capacity of the system relative to potential filter upgrades, and the significance of uncontrolled leakage into the building. Another consideration is the vulnerability of the HVAC system and components themselves, particularly when the facility is open to the public. For buildings under secure access, interior components may be considered less vulnerable, depending on the perceived threat and the confidence in the level of security.

1. Evaluate HVAC control options.

Many central HVAC systems have energy management and control systems that can regulate air flow and pressures within a building on an emergency response basis. Some modern fire alarm systems may also provide useful capabilities during CBR events. In some cases, the best response option (given sufficient warning) might be to shut off the building's HVAC and exhaust system(s), thereby avoiding the introduction of a CBR agent from outside. In other cases, interior pressure and air flow control may prevent the spread of a CBR agent released in the building and/or ensure the safety of egress pathways. The decision to install emergency HVAC control options should be made in consultation with a qualified HVAC professional who understands the ramifications of various HVAC operating modes on building operation and safety systems.

Depending on the design and operation of the HVAC system and the nature of the CBR agent release, HVAC control may not be appropriate in all emergency situations. Lobbies, loading docks, and mailrooms might be provided with man-

ually operated exhaust systems, activated by trained personnel to remove contaminants in the event of a known release, which exhaust air to an appropriate area. In other instances, manipulation of the HVAC system could minimize the spread of an agent. If an HVAC control plan is pursued, building personnel should be trained to recognize a terrorist attack quickly and know when to initiate the control measures. For example, emergency egress stairwells should remain pressurized (unless they are known to contain the CBR source). Other areas, such as laboratories, cleanrooms, or pressure isolation rooms in hospitals, may need to remain ventilated. All procedures and training associated with the control of the HVAC system should be addressed in the building's emergency response plan.

2. Assess filtration. Increasing filter efficiency is one of the few measures that can be implemented in advance to reduce the consequences of both an interior and exterior release of a particulate CBR agent. However, the decision to increase efficiency should be made cautiously, with a careful understanding of the protective limitations resulting from the upgrade. The filtration needs of a building should be assessed with a view to implementing the highest filtration efficiency that is compatible with the installed HVAC system and its required operating parameters. In general, increased filter efficiency will provide benefits to the indoor environmental quality of the building. However, the increased protection from CBR aerosols will occur only if the filtration efficiency increase applies to the particle size range and physical state of the CBR contaminant. It is important to note that particulate air filters are used for biological and radiological particles and are not effective for gases and vapors typical of chemical attacks. These

types of compounds require adsorbent filters (i.e., activated carbon or other sorbent-type media) and result in substantial initial and recurring costs.

Upgrading filtration is not as simple as merely replacing a low-efficiency filter with a higher efficiency one. Typically, higher efficiency filters have a higher pressure loss, which will result in some air flow reduction through the system. The magnitude of the reduction is dependent on the design and capacity of the HVAC system. If the air flow reduction is substantial, it may result in inadequate ventilation, reductions in heating and cooling capacity, or potentially frozen coils. To minimize pressure loss, deep pleated filters or filter banks having a larger nominal inlet area might be feasible alternatives, if space allows. Also, high-pressure losses can sometimes be avoided by using prefilters or more frequent filter change-outs. Pressure loss associated with adsorbent filters can be even greater.

The integrity of the HVAC system's filter rack or frame system has a major impact on the installed filtration efficiency. Reducing the leakage of unfiltered air around filters, caused by a poor seal between the filter and the frame, may be as important as increasing filter efficiency. If filter bypass proves to be significant, corrective actions will be needed. Some high-efficiency filter systems have better seals and frames constructed to reduce bypass. During an upgrade to higher efficiency filters, the HVAC and filtration systems should be evaluated by a qualified HVAC professional to verify proper performance.

While higher filtration efficiency is encouraged and should provide indoor air quality benefits beyond an increased protection from CBR terrorist events, the overall cost of filtration should be evaluated. Filtration costs include the periodic

cost of the filter media, the labor cost to remove and replace filters, and the fan energy cost required to overcome the pressure loss of the filters. While higher efficiency filters tend to have a higher life cycle cost than lower efficiency filters, this is not always the case. With some higher efficiency filter systems, higher acquisition and energy costs can be offset by longer filter life and a reduced labor cost for filter replacements. Also, improved filtration generally keeps heating and cooling coils cleaner and, thus, may reduce energy costs through improvements in heat transfer efficiency. However, when high-efficiency particulate air (HEPA) filters and/or activated carbon adsorbers are used, the overall costs will generally increase substantially.

3. *Ducted and non-ducted return-air systems.* Ducted returns offer limited access points to introduce a CBR agent. The return vents can be placed in conspicuous locations, reducing the risk of an agent being secretly introduced into the return system. Non-ducted return-air systems commonly use hallways or spaces above dropped ceilings as a return-air path or plenum. CBR agents introduced at any location above the dropped ceiling in a ceiling plenum return system will most likely migrate back to the HVAC unit and, without highly efficient filtration for the particular agent, redistribute to occupied areas. Buildings should be designed to minimize mixing between air-handling zones, which can be partially accomplished by limiting shared returns. Where ducted returns are not feasible or warranted, hold-down clips may be used for accessible areas of dropped ceilings that serve as return plenums. This issue is closely related to the isolation of lobbies and mailrooms, as shared

returns are a common way for contaminants from these areas to disperse into the rest of the building. These modifications may be more feasible for new building construction or buildings undergoing major renovation.

4. *Low-leakage, fast-acting dampers.* Rapid response, such as shutting down an HVAC system, may also involve closing various dampers, especially those controlling the flow of outdoor air (in the event of an exterior CBR release). When the HVAC system is turned off, the building pressure compared to outdoors may still be negative, drawing outdoor air into the building via many leakage pathways, including the HVAC system. Consideration should be given to installing low-leakage dampers to minimize this flow pathway. Damper leakage ratings are available as part of the manufacturers' specifications and range from ultra-low to normal categories. Assuming that you have some warning prior to a direct CBR release, the speed with which these dampers respond to a "close" instruction can also be important. From a protective standpoint, dampers that respond quickly are preferred over dampers that might take 30 seconds or more to respond.

5. *Building air tightness.* Significant quantities of air can enter a building by means of infiltration through unintentional leakage paths in the building envelope. Such leakage is of more concern for an exterior CBR release at some distance from a building, such as a large-scale attack, than for a directed terrorist act. The reduction of air leakage is a matter of tight building construction in combination with building pressurization. While building pressurization may be a valuable CBR-protection strategy in any building, it is much more likely to be effective in a tight build-

ing. However, to be effective, filtration of building supply air must be appropriate for the CBR agent introduced. Although increasing the air tightness of an existing building can be more challenging than during new construction, it should still be seriously considered.

Maintenance, Administration, and Training

Maintenance of ventilation systems and training of staff are critical for controlling exposure to airborne contaminants such as CBR agents.

1. *Emergency plans, policies, and procedures.* All buildings should have current emergency plans to address fire, weather, and other types of emergencies. In light of past U.S. experiences with anthrax and similar threats, these plans should be updated to include CBR attack scenarios and the associated procedures for communicating instructions to building occupants, as well as procedures for the following tasks: identifying suitable shelter-in-place areas (if they exist), appropriate selection and use of personal protective equipment (i.e., clothing, gloves, respirators), and directing emergency evacuations. Individuals developing emergency plans and procedures should recognize that there are fundamental differences between chemical, biological, and radiological agents. In general, chemical agents will show a rapid onset of symptoms, while the response to biological and radiological agents will be delayed.³ Issues such as designated areas and procedures for chemical storage, HVAC control or shutdown, and communication with building occupants and emergency responders should all be addressed. The plans should be as comprehensive as possible, but, as described earlier, protected by limited and controlled access. When

³Additional information on CBR agents may be found via the references at the end of this document.

appropriately designed, these plans, policies, and procedures can have a major impact on occupant survivability in the event of a CBR release. Staff training, particularly for those with specific responsibilities during such an event, is essential and should cover both internal and external events. Holding regularly scheduled practice drills, similar to the common fire drill, allows for plan testing, as well as occupant and key staff rehearsal of the plan, and increases the likelihood for success in an actual event. For protection systems in which HVAC control is done via the energy management and control system, emergency procedures should be exercised periodically to ascertain that the various control options work (and continue to work) as planned.

2. *HVAC maintenance staff training.* Periodic training of HVAC maintenance staff in system operation and maintenance should be conducted. This training should include the procedures to be followed in the event of a suspected CBR agent release. Training should also cover health and safety aspects for maintenance personnel, as well as the potential health consequences to occupants of poorly performing systems. Development of current, accurate HVAC diagrams and HVAC system labeling protocols should be addressed. These documents can be of great value in the event of a CBR release.
3. *Preventive maintenance and procedures.* Procedures and preventive maintenance schedules should be implemented for cleaning and maintaining ventilation system components. Replacement filters, parts, and so forth should be obtained from known manufacturers and examined prior to installation. It is important that ventilation systems be maintained and cleaned according to their manufacturers' specifications. To do this requires information on HVAC system

performance, flow rates, damper modulation and closure, sensor calibration, filter pressure loss, filter leakage, and filter change-out recommendations. These steps are critical to ensure that protection and mitigation systems, such as particulate filtration, operate as intended.

Conclusions

Reducing a building's vulnerability to an airborne chemical, biological, or radiological attack requires a comprehensive approach. Decisions concerning which protective measures to implement should be based on the threat profile and a security assessment of the building and its occupants. While physical security is the first layer of defense, other issues must also be addressed. Preventing possible terrorist access to outdoor air intakes and mechanical rooms, and developing CBR-contingent emergency response plans should be addressed as soon as possible. Additional measures can provide further protection. A building security assessment should be performed to determine the necessity of additional measures. Some items, such as improved maintenance and HVAC system controls, may also provide a payback in operating costs and/or improved building air quality. As new building designs or modifications are considered, designers should bear in mind that practical CBR sensors may soon become available. Building system design features that are capable of incorporating this rapidly evolving technology will most likely offer a greater level of protection.

While it is not possible to completely eliminate the risk of a CBR terrorist attack, several measures can be taken to reduce the likelihood and consequences of such an attack. Many of the recommendations presented here are ones that can be implemented fairly quickly and cost-effectively. Many are applicable to both new construction and existing buildings, although some may be more feasible than others. Building owners and managers should assess buildings by looking first for those items that may be (1) most vulnerable and (2) easily addressed. Addi-

tional measures should be implemented as possible. The goals are to make your building an unattractive target for a CBR attack and to maximize occupant protection in the event that such an attack occurs.

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Mention of any company, product, policy, or the inclusion of any reference does not constitute endorsement by NIOSH.

APPENDIX

Several organizations have developed guidance to assist building owners and operators in addressing issues related to building security and CBR terrorist attacks. Many other organizations have guidance that addresses security needs and disaster response plans for events such as fire, natural disasters, and bomb threats. While this latter guidance may not specifically address the terrorist threat to HVAC systems, readers may find portions of the information beneficial in establishing emergency response plans for their own buildings.

Table I provides a list of these organizations, though it is not all-inclusive. Available guidance is updated regularly as additional organizations and evolving technologies identify new protective recommendations.

TABLE I

Organizations that provide guidance on issues related to building security and indoor environmental quality

Organization	Reference or link	Description
National Institute for Occupational Safety and Health (NIOSH)	http://www.cdc.gov/NIOSH/homepage.html	Health and safety guidance, publications, and training information
Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov	Health guidance for CBR agents
U.S. Army Corps of Engineers (USACE)	http://BuildingProtection.sbcom.army.mil/basic (<i>Protecting Buildings and Their Occupants from Airborne Hazards</i>)	Presents a variety of ways to protect building occupants from airborne hazards
U.S. Environmental Protection Agency (EPA)	http://www.epa.gov/iaq/largebldgs/baqtoc.html (<i>Building Air Quality: A Guide for Building Owners and Facility Managers</i>)	Provides procedures and checklists for developing a building profile and performing preventive maintenance in commercial buildings
	http://www.epa.gov/iaq/schools (<i>Indoor Air Quality (IAQ) Tools for Schools Kit</i>)	Provides procedures and checklists for developing a building profile and performing preventive maintenance in schools

(Continued on next page)

TABLE I

Organizations that provide guidance on issues related to building security and indoor environmental quality (*Continued*)

Organization	Reference or link	Description
U.S. General Services Administration (GSA)	http://hydra.gsa.gov/pbs/pc/facilitiesstandards (<i>Facility Standards for the Public Buildings Service [PBS-P100]</i>)	Establishes design standards and criteria for new buildings, major and minor alterations, and work in historic structures for the Public Building Service; also provides information on conducting building security assessments
Central Intelligence Agency	http://www.cia.gov/cia/publications/cbrhandbook/cbr-book.htm (<i>Chemical, Biological, Radiological Incident Handbook</i>)	Unclassified document describing potential CBR events, recognizing potential CBR events, differences between agents, common symptoms, and information for making preliminary assessments when a CBR release is suspected
Lawrence Berkeley National Laboratory	http://securebuildings.lbl.gov	Website with advice for safeguarding buildings against chemical or biological attack
Federal Facilities Council (FFC)	http://www4.nas.edu/cets/ffc.nsf/web/chemical and biological threats to building?OpenDocument	Online notes and presentations from FFC seminar on chemical and biological threats to buildings
American Institute of Architects (AIA)	http://www.aia.org (<i>Building Security Through Design</i>)	An AIA resource center that offers architects and others up-to-date, in-depth material on building security issues
American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)	http://www.ashrae.org (<i>Risk Management Guidance for Health and Safety under Extraordinary Incidents</i>)	Draft report provides recommendations for owners and managers of existing buildings
American Society for Industrial Security	http://www.asisonline.org	Locates security specialists and provides the <i>Crises Response Resources</i> link to find information related to terrorism and building security
Building Owners and Managers Association	http://www.boma.org/emergency	Information on emergency planning and security assessments
	http://www.boma.org/pubs/bomapmp.htm (<i>How to Design and Manage Your Preventive Maintenance Program</i>)	Recommendations to effectively manage and maintain a building's systems (information for purchasing only)
International Facility Management Association (IFMA)	http://www.ifma.org	Information on security-related training courses
National Institute of Building Sciences (NIBS)	http://www.wbdg.org (<i>Whole Building Design Guide</i>)	Internet site featuring security-related design information