Guidance for

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

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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Department of Health and Human Services
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Foreword

The Occupational Safety and Health Act of 1970 [Public Law 91-596] assures so far as possible every working man and woman in the Nation safe and healthful working conditions. The Act charges the National Institute for Occupational Safety and Health (NIOSH) with conducting research and making science-based recommendations to prevent work-related illness, injury, disability, and death.

On October 8, 2001, the President of the United States established by executive order the Office of Homeland Security (OHS), which is mandated "to develop and coordinate the implementation of a comprehensive national strategy to secure the United States from terrorist threats or attacks." In January 2002, the OHS formed the Interagency Workgroup on Building Air Protection under the Medical and Public Health Preparedness Policy Coordinating Committee of the OHS. The Workgroup includes representatives from agencies throughout the Federal government, including NIOSH, which is part of the Centers for Disease Control and Prevention.

With U.S. workers facing potential hazards associated with chemical, biological, or radiological terrorism, the missions of the OHS and NIOSH overlap. As with most hazards, there are preventive steps that can reduce the likelihood and mitigate the impact of terrorist threats. Tried and proven principles in the control of airborne contaminants can be joined with similarly focused safety and security principles to provide guidance on how we design and operate our building environments. This document is the result of recent building vulnerability assessments conducted by NIOSH, as well as significant content and review recommendations provided by Workgroup members.

Prevention is the cornerstone of public and occupational health. This document provides preventive measures that building owners and managers can implement promptly to protect building air environments from a terrorist release of chemical, biological, or radiological contaminants. These recommendations, focusing on short-term actions, are only the beginning of a process to develop more comprehensive guidance. Working with the Building Air Protection Workgroup, as well as partners in the public and private sectors, NIOSH will continue to build on this effort. This document is a useful first step in the process.

Kathleen M. Rest, Ph.D., M.P.A.
Acting Director
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Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CBR	chemical, biological, or radiological
HVAC	heating, ventilating, and air-conditioning
VAV	variable air volume
CCTV	closed-circuit television
HEPA	high efficiency particulate air
NIOSH	National Institute for Occupational Safety and Health
OHS	Office of Homeland Security
PCC	Policy Coordinating Committee

Acknowledgments

The National Institute for Occupational Safety and Health (NIOSH) developed this document in cooperation with the Interagency Workgroup on Building Air Protection. NIOSH engineers Kenneth R. Mead, M.S., P.E. and Michael G. Gressel, Ph.D., C.S.P. are the principal authors. The Interagency Workgroup on Building Air Protection was formed under the Medical and Public Health Preparedness Policy Coordinating Committee (PCC) of the Office of Homeland Security (OHS). The Workgroup's purpose is to focus on building air protection issues associated with an airborne chemical, biological, or radiological (CBR) attack. Workgroup participants provided guidance and direction at several points during this document's development. Their diverse expertise and perspectives resulted in a set of real-world recommendations intended to increase protection of building environments from a terrorist's chemical, biological, or radiological attack. Participants on the Workgroup and their agency affiliations may be found in Appendix A.

In addition to the efforts of the Workgroup, the contributions of the NIOSH Research Team on Building Vulnerabilities are greatly appreciated. This team was augmented by representatives from Sandia National Laboratories and the Agency for Toxic Substances and Disease Registry (ATSDR). Many of the recommendations found in this document originated from the numerous vulnerability assessments conducted by this team. Members of the team are listed in Appendix B.

Anne Votaw, Pauline Elliott, Anne Stirnkorb, and Dick Carlson (NIOSH) provided editorial support, produced the camera-ready copy, and prepared the graphics. Review and preparation for printing were performed by Penny Arthur.

Guidance for

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

SCOPE

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 (for example, 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 about how to reduce their building's risk to a CBR attack. 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 at the end of this document 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 in the back of this document can provide information on how to recognize if a CBR release has occurred. These recommendations focus on airborne releases of CBR agents* 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 require much different measures and 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, the decisions concerning which protective measures should 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.

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

BACKGROUND

Terrorism events have increased interest in the vulnerability of U.S. workplaces, schools, and other occupied buildings to CBR threats. Of particular concern are the airflow patterns and dynamics in buildings, specifically in the building 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:

- 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. But it recognizes that some recommendations may not be feasible for you or in all situations.

In initiating any plan to modify building system design or operation, an important first step is to understand these systems: How were they intended to operate? How do they currently operate?

Getting to know your building may best be 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.* 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:

- 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?

Note: If 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.

- 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 airflow 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 "***" next to the number. As you review these recommendations, consider their potential implications upon 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 the 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 THE 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.

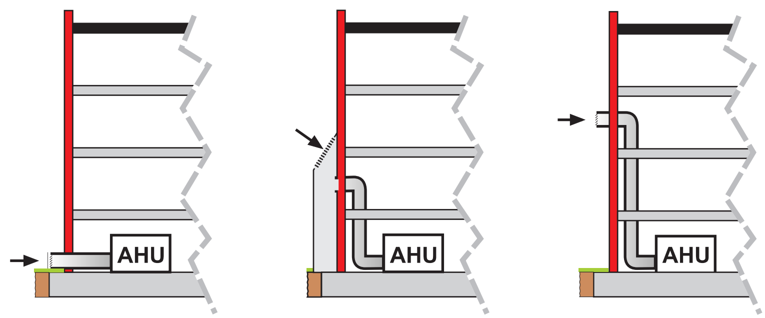
***3. DO NOT INTERFERE WITH FIRE PROTECTION AND LIFE SAFETY SYSTEMS. These systems provide protection in the event of fire or other types of events. They should not be altered without guidance from a professional specifically qualified in fire protection and life safety systems.

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 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 or 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 understand what assets require protection and 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:

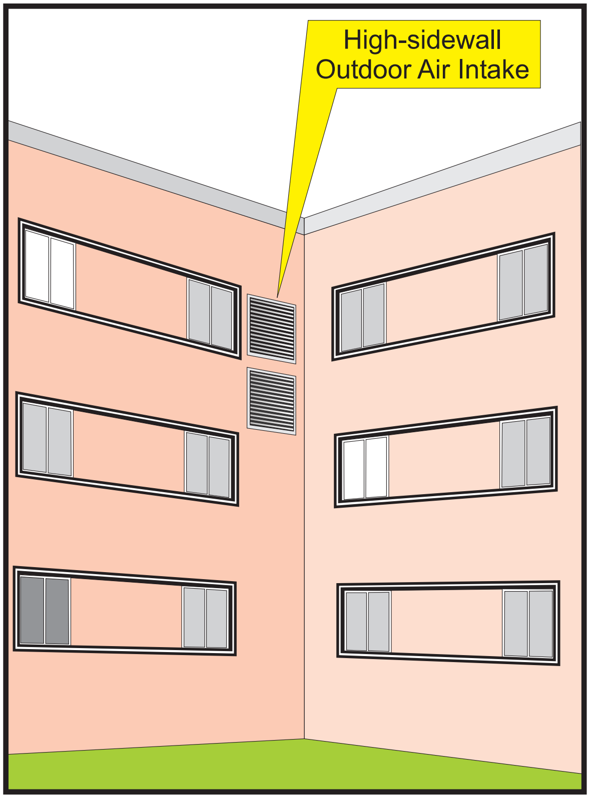
***1. Prevent access to outdoor air intakes. One of the most important steps in protecting a building's indoor environment is the security of the outdoor air intakes. Outdoor air enters the building through these intakes and is distributed throughout the building by the HVAC system. Introducing CBR agents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

Protecting Outdoor Air Intakes



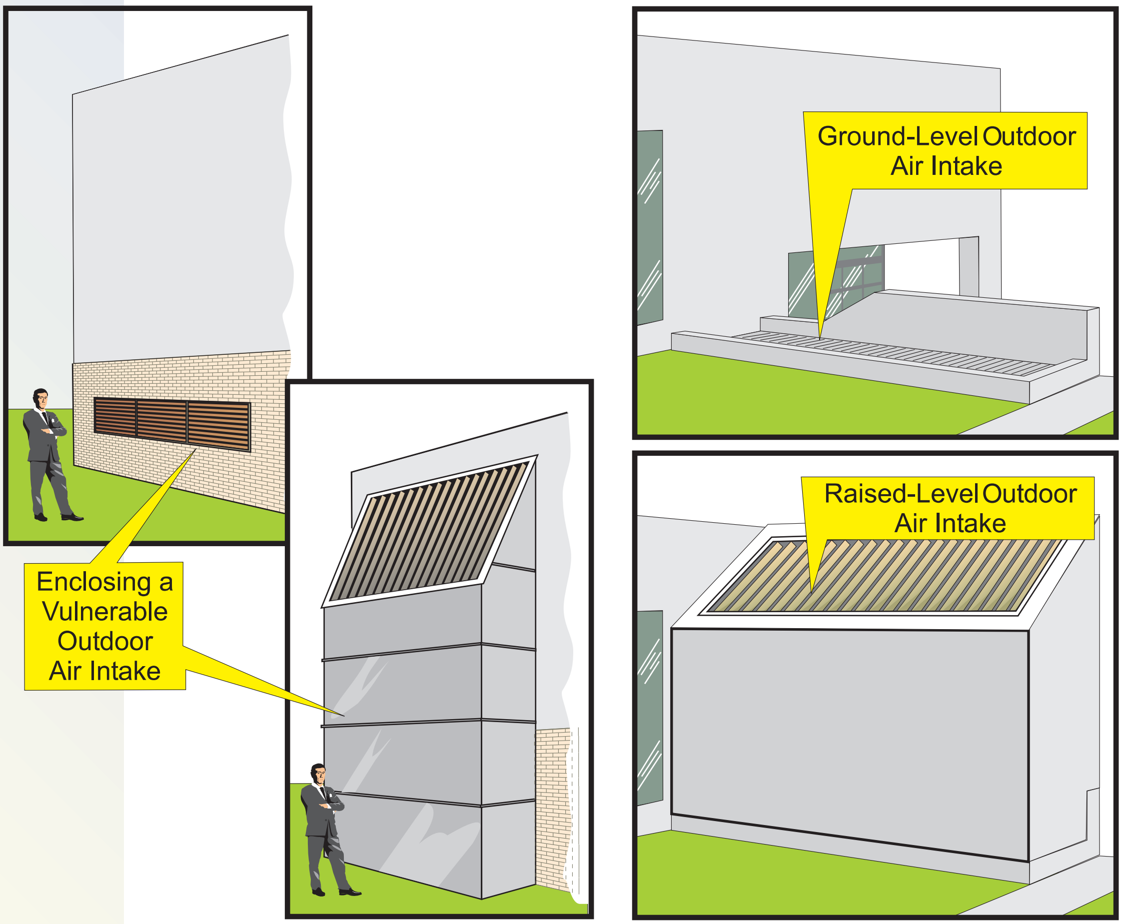
Relocate outdoor air intake vents. Relocating accessible air intakes to a publicly inaccessible location is preferable. Ideally, the intake should be located on a secure roof or high sidewall. The lowest edge of the outdoor air intakes should be placed at the highest feasible level above the ground or 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.

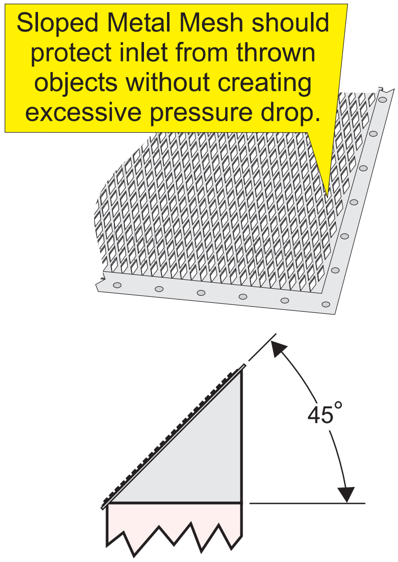
Extend outdoor air intakes. If relocation of outdoor air intakes is not feasible, intake extensions can be constructed without creating adverse effects on HVAC performance. Depending upon budget, time, or the perceived threat, the intake extensions may be temporary or constructed in a permanent,



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 considered. An extension height of 12 feet (3.7 m) will place the intake out of reach of individuals without some assistance. 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. 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, 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. 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.





This figure shows the minimum recommended inlet angle of 45 degrees. Extensions with greater inlet angles may provide greater inlet protection while increasing the inlet face area.

***2. PREVENT PUBLIC ACCESS TO MECHANICAL AREAS. Closely related to the relocation of outdoor air intakes is 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, keycards, 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 person. 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 (includes 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 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 (those having lobbies with elevator access, for example), establishing a negative pressure differential will present a challenge. A qualified HVAC professional can assist in determining if 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 intake, HVAC return-air grilles that are publicly accessible and not easily observed by security may be vulnerable to targeting 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 pre-screened 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 upon 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 airflow 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), thus, avoiding the introduction of a CBR agent from outside. In other cases, interior pressure and airflow 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 that understands the ramifications of various HVAC operating modes on building operation and safety systems.

Depending upon 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 manually operated exhaust systems, activated by trained personnel to remove contaminants in the event of a known release, exhausting 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 to 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, clean rooms, 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 airflow reduction through the system. The magnitude of the reduction is dependent on the design and capacity of the HVAC system. If the airflow 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 changeouts. 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 upon 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 the return plenum. 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 those 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 manufacturer's 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 building. 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 consider CBR attack scenarios and the associated procedures for communicating instructions to building occupants, identifying suitable shelter-in-place areas (if they exist), identifying appropriate use and selection 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.* 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 appropriately designed, these plans, policies, and procedures can have a major impact upon occupant survivability in the event of a CBR release. Staff training, particularly for those with specific responsibilities during an event, is essential and

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

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 the manufacturer's 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 upon 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 done 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 consider 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 reasonably 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 are most vulnerable and can be addressed easily. Additional measures should be implemented as feasible. 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.

For Additional Information

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 their own building's emergency response plans.

The following list is not all-inclusive. Available guidance is updated regularly as additional organizations and evolving technologies identify new protective recommendations.

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.sbccom.army.mil/basic/ *Protecting Buildings and Their Occupants from Airborne Hazards*	Document 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 *Building Air Quality: A Guide for Building Owners and Facility Managers*	Provides procedures and checklists for developing a building profile and performing preventive maintenance in commercial buildings.
	http://www.epa.gov/iaq/schools/ *Indoor Air Quality (IAQ) Tools for Schools Kit*	Provides procedures and checklists for developing a building profile and performing preventive maintenance in schools.
U.S. General Services Administration (GSA)	http://hydra.gsa.gov/pbs/pc/facilitiesstandards/ *Facility Standards for the Public Buildings Service (PBS-P100)*	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/cbr_handbook/cbrbook.htm *Chemical, Biological, Radiological Incident Handbook*	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	Web site 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_buildings?OpenDocument	Online notes and presentations from FFC seminar on chemical and biological threats to buildings.
American Institute of Architects (AIA)	http://www.aia.org *Building Security Through Design*	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/ *Risk Management Guidance for Health and Safety under Extraordinary Incidents*	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 *Crises Response Resources* 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 *How to Design and Manage Your Preventive Maintenance Program*	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)	www.wbdg.org *Whole Building Design Guide*	Internet site featuring security-related design information.

APPENDIX A

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