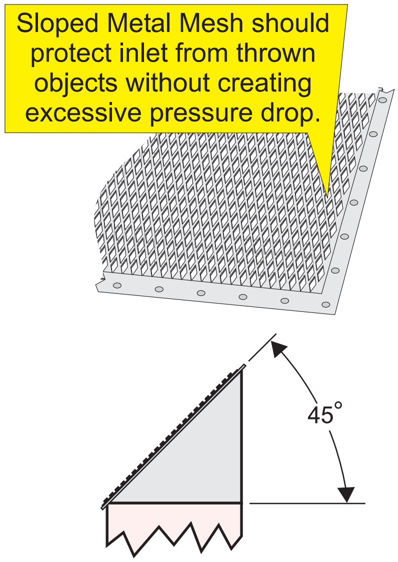

This figure shows the minimum recommended inlet angle of 45 degrees. Extensions with greater inlet angles may provide greater inlet protection while increasing the inlet face area.

***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 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 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/cbr-book.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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DHHS (NIOSH) Publication No. 2002-139