ASHRAE®

GUIDELINE

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Guideline for the Risk Management of Public Health and Safety in Buildings

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NOTE

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(This foreword is not a part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

FOREWORD

Risk management of extraordinary incidents is a critical step in the process of establishing project goals and programs in the design and operation of new facilities or the renovation of existing facilities. This process will assist in determining what facility protection measures are appropriate to mitigate potential threats to meet the decision maker's operational needs at an acceptable cost. Methods described in this guideline show how analyses can be performed to assist the decision maker in this process. The guideline focuses primarily on office and multifamily residences as opposed to industrial or specialty designs such as transportation or detention facilities.

While several International Organization for Standardization (ISO) standards currently exist for emergency preparedness, they deal primarily with high-level recommendations for development of risk management plans. ASHRAE provided "initial guidance on actions that should be taken to reduce the health and safety risks of occupants in buildings that might be subject to extraordinary incidents" in its Report of Presidential Ad Hoc Committee for Building Health and Safety under Extraordinary Incidents, dated January 26, 2003. This initial guidance raised the awareness of the possibility of the occurrence of terrorist-like acts and addressed the tools necessary to design a system that would provide better protection of material and/or human assets. Events such as the 2008 hotel attack in Mumbai and the U.S. embassy attacks in Sanaa and Jeddah, among others, highlight the increased vulnerability of Americans with shifting social mores around this country and the world.

There have been many studies and reports that provide more specific guidance in many subject areas, especially the FEMA Risk Management Series, including FEMA 426, Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings*, but they do not all provide comprehensive guidance in many subject areas. Few provide a holistic overview of the pieces that are within the purview of the HVAC design professional and are integrated with the architecture of the building. This guideline recognizes that all of this is to be performed in conjunction with ongoing requirements such as remaining within budgets, providing customer satisfaction, improving indoor air quality (while also potentially mitigating threats of biological and chemical airborne agents), and minimizing environmental impacts for both new and existing facilities.*

Many of the concerns that design professionals face during the normal project development cycle (wind load, seismic levels, etc.) lead them to create safe and secure facilities. Mitigation of terrorist threats may also be beneficial in these areas and serve as an enhanced multihazard approach that may be more easily justified in the project budget. This guideline provides information that encourages us to take the next step and consider the value of the assets that we are designing around—our people, our physical assets, and our continued business operations.

1. PURPOSE

The purpose of this guideline is to provide guidance for the practical evaluation, design, and implementation of measures to reduce multiple *risks* in new and existing buildings.

2. SCOPE

This guideline contains qualitative and quantitative methods for management of the *risk* of *extraordinary incidents* in buildings. Specific subject areas of concern include air, food, and water. The extraordinary events addressed in this guideline include fire, seismic event, chemical and biological release, blast, and other extraordinary hazards. The guideline will address *extraordinary incidents* from a multihazard perspective and will cover both intentional and accidental occurrences. The guideline addresses aspects of building performance that affect occupant health and safety, including egress; chemical, biological, and radiological (CBR) protection; fire protection; smoke removal or purging; filtration; air quality; entrance paths for contaminants; and building envelopes.

3. DEFINITIONS

Definitions of most terms used in this guideline may be found in *ASHRAE Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration* [1].

Terms used in this guideline that are not found in *ASHRAE Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration*, or that are used differently, are defined in this section and are italicized in the body of the guideline.

area of refuge: an area that is protected from the effects of fire or other hazards, either by means of separation from other spaces in the same building or by virtue of location, thereby permitting a delay in egress travel from any level.

dedicated outdoor air: a ventilation system that delivers 100% outdoor air to each individual space in a building at flow rates equal to or greater than required by ANSI/ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality* [2].

extraordinary incidents: events or conditions that exceed those upon which locally accepted design practice is based.

hardening: reinforcement of the building structure and systems against impact of a blast, a ballistic assault, or ramming.

risk: the probability of suffering harm or loss.

terrorism:

> any action... that is intended to cause death or serious bodily harm to civilians or noncombatants, when the purpose of such an act, by its nature or context, is to intimidate a population, or to compel a government or an international organization to do or to abstain from doing any act [3].

threat: an indication of impending danger.

vulnerability: susceptibility to physical injury or *threat*.

4. RISK MANAGEMENT APPROACH

4.1 General Approach. *Risk* management is a systematic approach to the discovery and management of *risks* facing an organization or facility. It includes the identification of sources

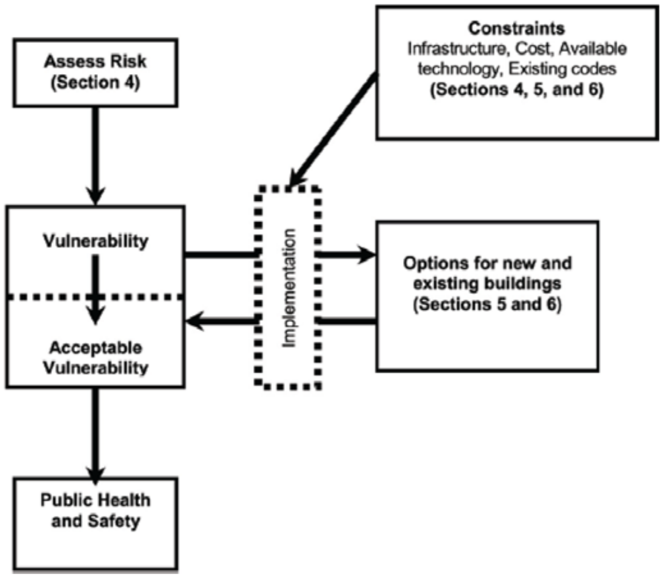

Figure 1 Risk management framework [4].

of *threat* and the characterization of the likelihood of the occurrence of the incidents of concern if these *threats* are carried out. The overall goal of *risk* management is to identify and mitigate *risks* and to minimize the consequences of incidents that cause harm or result in potential losses to the enterprise. The process should objectively state, document, and rank *risks*; prepare a plan for implementation to reduce these *risks*; and conduct periodic reviews of the *risks* and the plan's relevance to any changes in those *risks*. This section presents an approach to achieve this objective. The ranking of *risks* needs to consider both the likelihood of incidents taking place and the potential severity of their consequences.

The *risk* management approach in this guideline is general in nature and should be implemented to fit the situation. This guideline is not intended to be a mandatory document. The chosen approach may take many forms. Some organizations may take a formal and detailed approach, while others may take an informal and simpler approach. An example of the *risk* management methodology is provided in Informative Appendix A.

This *risk* management approach is based on the framework shown in Figure 1. In this framework, the first step is to evaluate the *risk* to a facility posed by various *threats*. Based on the level of *risk*, an assessment is conducted of the *vulnerability* of a given building to an incident. For example, a building located next to railroad tracks is more vulnerable to a hazardous chemical leak resulting from a train derailment. All facilities are vulnerable to a degree. The decision maker determines the level of acceptable *vulnerability* for a given facility and decides, for each *threat*, whether it must be addressed or whether the potential losses it might cause can be accepted due to the level of likelihood, the impracticality of implementation, or the high cost of protection.

Proper use of *risk* management should include the following features (see Informative Appendix A for more information):

a. Identifies which *risks* are the most critical
b. Determines which *risks* require the most resources
c. Offers flexibility and can be adapted to an organization's needs and resources
d. Creates a written history of *threat* and *risk* assessment, mitigation evaluation, implementation, and feedback
e. Encourages discussion about *risk*, requirements, and technologies
f. Promotes periodic review to ensure the organization's needs are met
g. Involves diverse groups that bring a broad range of experience and expertise to mitigate the *risks*

The *risk* management process includes the following four steps [5]:

a. *Risk* assessment
b. *Risk* management planning
c. *Risk* management plan implementation
d. Re-evaluating the plan after implementation, and modifying it as needed

The first step, *risk* assessment, identifies the *threats*, the value of the probable losses, and system *vulnerabilities*. The second step identifies options that can reduce *vulnerabilities*, mitigate the *risks*, and provide protection to acceptable levels (criteria). These options are then analyzed for their impact on total system performance and estimated cost, and prioritized for implementation. In the third step, the options are organized into a coherent plan, which leads to their installation and commissioning. In the fourth step, the plan is re-evaluated periodically to ensure that it meets current needs. If or when the performance of the installed system is found to be insufficient, the four-step process is repeated.

4.2 Risk Assessment. *Risk* assessment is a multitask process:

a. Identify the decision maker.
b. Conduct a *threat* assessment.
c. Conduct a *vulnerability* assessment.
d. Assign a *risk* category.
e. Establish criteria.
f. Calculate the loads imposed by *threats*.
g. Develop and evaluate intervention (alternative solutions).
h. Determine if the criteria are met.
i. Select the intervention to use.
j. Run the assessment using multiple *threats*.

4.2.1 Identify the Decision Maker. Identify the decision maker, the individual or group responsible for defining the following:

a. Measurable parameters of possible harm or loss
b. The values of the parameters
c. Acceptable *vulnerability* in terms of these measurable parameters and values

Measurable parameters of possible harm or loss include, but are not limited to, the following:

a. Loss of life
b. Loss of property or revenue
c. Loss of profits
d. Loss of labor hours

Table 1 Examples of Threats

Types of Threats			
		Intentional	
Natural	**Accidental**	**Criminal**	***Terrorism***
Flood	Flood	Arson	Blast
Wind	Fire	Sabotage	Chemical, biological, and radiological
Quake	Spills	Vandalism	Utility
Fire		Cyber attacks	Electronic
		Hostages and kidnappings	

e. Loss of business
f. Loss of key personnel
g. Cost of recovery

The *risk* management decision maker is responsible for any measurable parameters of possible harm or loss, including, but not limited to, potential injuries; loss of life, property, revenues, profits, or labor hours; and cost of recovery.

4.2.2 Conduct a Threat Assessment. The *threat* assessment should identify the types of incidents (see Table 1 for example *threats*), their probabilities, and their impacts that present a *risk* to the facility.

4.2.3 Conduct a Vulnerability Assessment. The *vulnerability* assessment identifies susceptibilities in the facility's systems and estimates the probability that the *threat* can occur and cause harm, the extent of the damage, and the loss in terms of cost.

4.2.4 Assign a Risk Category. The *risk* categories for the purpose of this guideline are as follows:

a. **Critical.** An incident that, if it occurred, would cause failure of the performance of the facility or would have a major impact on occupant health and safety.
b. **Serious.** An incident that, if it occurred, would cause a major disruption in the performance of the facility or would have a significant impact on occupant health and safety.
c. **Moderate.** An incident that, if it occurred, would cause significant disruption in the performance of the facility or would have some impact on occupant health and safety.
d. **Minor.** An incident that, if it occurred, would cause only a small disruption in the performance of the facility; some temporary occupant discomfort might occur, but there would be no impact on occupant health and safety.
e. **Negligible.** An incident that, if it occurred, would have little or no effect on the performance of the facility and no impact on occupant health and safety.

Consider obtaining guidance from experts on the diverse hazards that are to be addressed in any specific project or application so that advantage is gained of the vast knowledge that has accumulated. *Risks* should be quantified more precisely so that appropriate cost-benefit trade-offs and life-cycle analysis can be prepared to inform design decisions and advice rendered to the ultimate decision maker, the engineer's client.

4.2.5 Establish the Evaluation Criteria. The decision maker, together with the design professional, needs to consider many factors in establishing the criteria by which the performance of the facility, including the impact on the occupants, will be evaluated. These criteria should include, but not be limited to, the following:

a. Health
b. Safety
c. Welfare
d. Exposures
e. System performance
f. Economy

The evaluation criteria are defined in terms of parameters and values that are based on the *risk* categories. Examples of preselected evaluation criteria are building, fire, plumbing, mechanical, and electrical codes.

4.2.6 Calculate the Loads Imposed by the Threat. Loads are imposed by thermal, seismic, acoustical, electrical, physical security, and other forces, as well as gravity, wind, flood, water, and fire. The loads are calculated by methods used by structural, mechanical, and electrical engineers, and other disciplines. The loads determine the sizes and capacities of the systems needed to achieve the criteria set in Section 4.2.5 and the *risk* categories assigned in Section 4.2.4.

4.2.7 Develop and Evaluate Intervention. The design professional develops and evaluates the cost of the intervention (alternate solutions) that the *risk* category and evaluation criteria dictate (Sections 4.2.4 and 4.2.5) and presents them to the decision maker. For example, where flooding is concerned, the design professional could develop a list of options to mitigate the effects of flooding, such as moving everything to the second or third floor, installing pumps, and providing levees and flood control gates around and within the site. Evaluation may include cost, aesthetics, convenience, etc. See Informative Appendix D.

4.2.8 Determine whether the Criteria are Met. If the criteria are met, then the intervention can be passed through to the next task. If not, then return to task four (Section 4.2.4).

4.2.9 Select the Interventions that Meet the Criteria. The decision maker is accountable for the final selection of the intervention. The design professional should provide all documentation to assist the decision maker's final selection.

4.2.10 Conduct the Assessment Using Multiple Threats. Evaluate the completed plan selections with the multiple *threat* scenarios, such as those characterized in Section 4.2.2. One example would be to test an emergency generator system during a power outage and flood conditions. If the systems meet the criteria, then it passes the test. If it fails, then modification or a new system may be needed.

The *risk* assessment model presented here is a conceptual process. Refer to Informative Appendix A and the bibliography in Informative Appendix B for more in-depth material.

4.3 Risk Management Plan Implementation. The information from the *risk* assessment (Section 4.2) can be used to develop an implementation plan. The selected set of interventions should then be installed and commissioned.

4.4 Re-Evaluating the Plan after Implementation. The plan should be reviewed periodically to ensure its effectiveness. If a plan is not meeting its objectives, either the plan or the objectives should be modified. One sign of a successful plan is its continual review and modification to meet the user's needs. If or when the performance of the installed system is found to be less than expected, the *risk* management process described in this section should be repeated.

5. DESIGN FOR NEW AND EXISTING FACILITIES

5.1 General Concepts. The concepts in this section should be considered for protection of the occupants of the facilities and site from *extraordinary incidents* in addition to requirements in local codes, industry standards, and ordinances, and good planning and design practice.

The decision maker should determine the human and financial resources available to attain the level of protection determined during the *risk* management process in Section 4. The design professional should not assume the burden of making these determinations.

5.1.1 Design Issues and Strategies. Constraints and *vulnerabilities*, both outside and inside the building, can impact the effectiveness of air, water, and food processing control during normal and extraordinary operating conditions, which may impact decisions regarding various proactive and reactive response strategies.

The protective measures are determined by the constraints and *vulnerabilities* of the (a) building site, (b) utility systems, (c) building components and systems, and (d) types of tenant occupancies.

5.1.2 Renovations. Wherever possible, the guidelines for new facilities are also desirable for existing facilities and should be applied to renovation projects. However, some of these recommendations may not be achievable in existing facilities. The design professional should consult with the decision maker and conduct a *vulnerability* assessment using the guidelines in Section 4. The decision maker should determine the level of acceptable *risk* given the *vulnerability* of the facility and the cost of correction in construction and downtime. If seismic or blast loading are considered *threats*, and the building has not been designed for either, the feasibility and cost of upgrading the structure should be explored using existing technologies. The design professional should make clear to the decision maker any adaptations deemed necessary due to the physical limitations of the existing conditions and, where appropriate, the cost or savings of complying with these guidelines.

5.2 Site Planning and Design

5.2.1 Site Selection. Site planning begins with site selection. In addition to the usual precautions in selecting a building site, such as avoiding flood plains, wetlands, poor subsoil conditions, and seismically active locations, consideration should be given to selecting a site that has minimal exposure to the *threats* identified in the *threat* and *risk* assessments.

Relevant considerations include the following:

a. Proximity of railroads and highways where hazardous materials may be transported
b. Takeoff and landing patterns for airports
c. Storage and processing of hazardous materials such as fuels and hazardous chemicals
d. Proximity of occupancies potentially attractive to terrorist attacks, such as government facilities
e. Traffic patterns and approaches to the site that allow high-speed approaches
f. *Vulnerability* to failure of adjacent buildings and other structures
g. *Vulnerability* to hazards from construction adjacent to or below the building, such as underground sewer and water mains, transit lines, parking structures, etc.

5.2.2 Site Access. The site perimeter adjacent to existing or planned vehicular rights-of-way should allow space for vehicular barriers to prevent accidental or intentional breach of the site perimeter. Whether or not the *threat* and *risk* assessments indicate vehicle ramming as a *threat*, prudent site selection will consider the potential for future needs. These may include natural barriers such as berms, ditches, steep grades, water, and heavy forest, or constructed barriers such as walls, cables, bollards, and street furniture (benches, poles, etc.). The presence of subterranean structures at the perimeter should be ascertained because they might interfere with proper anchorage of barrier foundations.

The site perimeter should allow for personnel barriers, such as fences and walls, for facilities of **moderate *risk*** and higher.

For **moderate *risk*** and higher, the site should have access from two or more public rights-of-way to permit alternative routes for evacuation and emergency access.

For **serious *risk*** and higher, consideration should be given to the monitoring of all access points by methods such as guards, alarms, cameras, or other security hardware. Site entrances should allow for the use of screening of vehicles and pedestrians without encumbering adjacent public rights-of-way with waiting traffic.

5.2.3 Siting of Buildings

5.2.3.1 Recommendations for Moderate Risk and Higher. Buildings should be located a sufficient distance from uncontrolled vehicles to mitigate the effects of a blast determined by the *threat* and *risk* assessments.

Approach roads for vehicles to the site should permit space for screening at an entrance control area with adequate queuing for peak-period arrivals on site. On-site roads leading to occupied facilities should be designed to limit speed of approach. Barriers should be provided to prevent vehicles from approaching occupied facilities nearer than 30.0 m (100 ft) and be capable of resisting attempted crashing by a vehicle determined by the *threat* and *risk* assessments. In any case, means of access by emergency vehicles, such as to fire lanes, should be maintained by control devices operable by keys kept in secure containers for emergency personnel.

Adequate maneuvering space and dock space for delivery vehicles should be provided.

The following should be kept as far as possible (or as necessary to mitigate the *threat* identified in the *threat* and *risk* assessments) from uncontrolled public rights-of-way and from delivery vehicles on site:

a. Main electrical power entrance(s)
b. Emergency power generation
c. Communication services
d. Potable and fire protection water entrances
e. Emergency egress doors from the building

Litter and trash bins and postal collection boxes should be kept a minimum of 30.0 m (100 ft) from occupied facilities.

Site lighting should be designed to perform the required functions. The following are examples of effective site lighting levels: at vehicular and pedestrian entrances, 160 lux (15 fc), horizontally maintained, and for perimeter and vehicular and pedestrian circulation areas, 54 lux (5 fc), horizontally maintained. In most circumstances, perimeter lighting should be continuous and on both sides of the perimeter barriers and sufficient to support closed-circuit television (CCTV) and other surveillance. However, for safety reasons and/or for issues related to camera technology, other lighting levels may be desirable. Other codes or standards may address site lighting levels. Where codes and standards otherwise limit site lightening levels, apply for an exemption.

5.2.3.2 Recommendations for All Risk Levels. Passenger vehicle parking and drop-off/pickup should be kept as distant from one another as possible (or as distant as necessary to mitigate the *threat* identified in the *threat* and *risk* assessments) while providing convenient access for all persons, including those with disabilities.

Where the site includes facilities for children, such as child care or schools, and outdoor areas, including playgrounds and drop-off/pick-up points, they should be located where visible to supervisory personnel.

Where the site is served by or adjacent to an active railroad, occupied facilities and vital utility and emergency services should be located as far away as possible (or at a distance required to mitigate the *threat* as determined by the *threat* and *risk* assessments) to avoid proximity to derailments and spills.

Access by unauthorized persons to solid waste containers should be restricted by enclosure of the service yard containing them.

Confusion due to signage over site circulation, parking, and entrance locations can contribute to a loss of site security. Provide clear signage off-site and at entrances, provide on-site directional signs, parking signs, and provide cautionary signs for visitors, employees, service vehicles, and pedestrians. Unless required by other standards, do not provide signs that identify sensitive areas.

Buildings should be arranged on site with adequate space between them to permit access by emergency vehicles, to prevent migration of fire, and as mandated by local codes and ordinances.

Landscaping should be designed to avoid places of concealment adjacent to occupied facilities or vital support facilities and on pathways to and from facilities, parking lots, and site entrances. Where perimeter fences or walls are provided, landscaping should likewise not afford places of concealment nor provide a means of scaling the fence or wall by use of branches.

5.2.4 Site Parking and Garages. For proposed facilities with **moderate *risk*** or lower, the design professional should determine whether parking spaces or garages may be constructed directly adjacent to or under an occupied facility. Garages should not be constructed adjacent to or beneath occupied floors of buildings of **moderate *risk*** or higher. Consider surveillance cameras for **serious *risk*** or higher.

5.3 Utility Systems

5.3.1 General Considerations. On-site utility failures happen occasionally but usually on a manageable scale. Most facilities make provisions for these failures or disruptions as a part of design, regular maintenance, or periodic renovation. However, it may be necessary to perform specific *risk* and *vulnerability* assessments of facilities to determine the extent to which the function of any particular facility can be compromised by *extraordinary incidents*. If this is the case, detailed planning may be needed that uses what-if scenarios to examine the consequences of unusual and/or multiple situations.

For those items or services that are expected to fail periodically based on experience, spare parts or systems are sometimes kept on site unless they are known to be readily available locally. Replacing items or services when the failures are unexpected can take weeks or months. Also, depending on the extent of an incident, which can sometimes impact a whole city or even larger area, unusually high demand or interruptions in transportation services may also lead to longer delivery times.

Many of the utility issues are interdependent, and, for this reason, failure, disruption, or reduction in any one service can impact the others. For example, many communication systems rely on electric power for operation. Thus, an electric outage can also mean that communications are not available. As contingency plans are considered to deal with these issues, these interdependencies should be kept in mind.

Some experience has been gained for dealing with most of these issues by responding to ordinary utility outages, strikes, natural occurrences, or other expected unreliability. While the relative *risk* of being impacted by terrorist attacks or other *extraordinary incidents* may be low in an individual building, this possibility and the potential impacts on a building should not be overlooked. Many facilities incorporate some features to back up a utility and can include simple items, such as battery-backup power supplies for computers and communications equipment, as well as more complex and expensive safeguards, such as generators, redundant electricity, communications, water service, or combustion-driven heating and cooling. If the *risk* of utility interruption is judged to be sufficiently high, a greater number of redundant or backup features may be desirable and justifiable.

5.3.2 Single Point for Disconnecting Utilities. Consider providing a single point for disconnecting or shutting off critical utilities such as natural gas and electrical supplies to the facility. The shut-off points should be clearly identified and readily available to the emergency response personnel (i.e., trained personnel who first arrive on the scene) to an *extraordinary incident* but not to intruders. Automatic shut-off valves are already required for gas piping in seismic zones.

5.3.3 Electric Service. Power substations, transformer vaults, and enclosures supplying the facility should be secured from access by unauthorized persons. Services from utilities such as power and communications should be underground where feasible.

Switchgear, motor control centers, power distribution panels, and generators should be secured against unauthorized entry. All electrical equipment for a site or facility should be protected against potential flooding and seismic events.

A single electric distribution circuit from a utility is the most likely service to facilities. Where reliability is a concern, consider service redundancy by having two utility substations. While many substations have multiple feeds, reliability of electric service can be disrupted by failure of the substation or the distribution circuit. Standby generators should be provided with sufficient fuel storage when essential operations must continue to function during a commercial power failure. The period of storage should be determined from the *threat* and *risk* assessments. For **moderate *risk*** and higher, seven days of storage should be considered. Critical facilities, such as hospitals and emergency response centers, should consider even longer storage periods.

5.3.4 Water. For **moderate *risk*** and lower, all water lines should be controlled against unauthorized access. Water storage tanks for potable water and fire suppression storage tanks, if they exist, should be secured against unauthorized access and designed for seismic loading and blast loading where relevant.

For **moderate *risk*** and higher, where water supply quantity or pressure may be inadequate, consider providing storage tanks and fire pumps. Also, consider how the fire pump will be energized—should it be electric, gas, or diesel-fueled?

For **serious *risk*** and higher, and if continuous water supply is required for the operation of a facility, consider providing a water well and/or on-site water storage. These supplemental facilities should be protected against unauthorized access, and on-site piping needs to be constructed according to the local or state public health and plumbing codes.

5.3.5 Sewer. Disruption of the sewer service is noticed almost immediately. A backflow preventer valve is usually required by code and will prevent the sewage from flowing back into the building or site system if there is a disruption in the sanitary sewers. A sewage storage reservoir and/or sewage sump pump should be considered if there is a need for continued operations in a facility.

5.3.6 Storm Drainage. Removal of storm water from facilities by public systems is subject to disruption by blocking flow, thus causing storm water to back up and flood buildings and streets. Having alternate means for storm water disposal, such as retention ponds, may provide some relief. Blocking of natural watercourses can also cause flooding in areas never before considered. Siting of critical buildings or occupied portions of buildings in areas where flooding is likely by natural or man-made causes should be avoided (see Section 5.2.2).

5.3.7 Natural Gas. Natural gas systems serving facilities can be disrupted by pipeline breaks or explosions or by loss of pumping or compressor stations that move the gas. Having alternate fuel supplies for some natural gas equipment, such as propane or fuel oil, can allow limited continued operation. The gas meter and shut-off/isolation valves should be located in a secure, monitored area.

5.3.8 Fuel Storage. On-site storage of fuels is a potential target for intentional attacks and is vulnerable to natural and accidental incidents. Access manholes to underground fuel oil or gasoline storage tanks should be protected from and monitored for unauthorized access. The access manholes and tank vents should also be raised to protect against flooding. Aboveground fuel storage should also be protected from and monitored for unauthorized access.

5.4 Building Planning and Design

5.4.1 General Considerations. Building design needs to comply with applicable codes and ordinances and should adhere to applicable ASHRAE standards. Buildings are routinely designed to comply with acceptable criteria for health and life safety of the occupants; to be comfortable; to provide pleasant environments; to result in building and equipment energy efficiency; and to accommodate ease of constructability, maintainability, and accessibility of equipment and system components. The recommendations of this guideline are in addition to these, but should not conflict with the fire and life safety protections afforded by the applicable codes and ordinances. In all planning and design of facilities, the safety of the occupants, through minimizing injuries and fatalities, is paramount. Safe egress and evacuation following an *extraordinary incident* should be maximized by the design. Emergency personnel and equipment must be able to access the building.

It is important to design a layered protective system so that various parts of the system remain effective when components are taken out of service for maintenance or repair. For instance, the building can be designed with discreet zones so that the building remains pressurized when one of the building's air-handling units is being maintained or repaired. Thus, no one part of the building protective system should be the only means of protection for the health and safety of the building occupants.

5.4.2 Building Envelope. Building envelopes should be designed to control energy transfer and to minimize air and vapor transport. A building envelope that meets these needs is also likely to provide some reduction in *vulnerability* to *extraordinary incidents*. Verifying the integrity of the building exterior envelope through testing is essential to ensuring that a new or renovated building envelope will provide a good barrier to energy and mass transfer. If the existing building envelope is being retained as part of a renovation project, sealing the building envelope to reduce air leakage may be justified based on energy savings and comfort.

5.4.2.1 Blast, Seismic, and Wind. When blast is identified as a *threat* in the *threat* and *risk* assessments, blast design criteria should be as recommended below. Generally, the blast pressure decays exponentially with distance of the building from the blast source. In site selection and planning, therefore, measures that accomplish distance from blast sources should be employed wherever possible and where it has been determined that the cost of additional land to obtain greater standoff is not greater than the cost of blast *hardening* the building as recommended below. Blast mitigation design should be performed by experienced blast design professionals. The design of the building envelope to mitigate blast involves all components—window glazing, window frames, anchors, spandrel construction, and main structure. It should be noted that while wind and seismic design can improve a building's response to blast, blast mitigation is not the same as designing for wind and seismic mitigation. Because designs for blast mitigation can affect the thermal performance of building envelopes, blast and thermal performance should be evaluated as interactive effects.

Wind loads for the design of structure and exterior elements are specified in most building codes for the geographical area where the building is to be built. In high-wind areas, such as those subject to hurricanes, design should consider both blast and wind loads, with the analysis performed by a professional structural engineer.

The seismic design that is required in the local codes and ordinances may improve building performance under blast loads but generally will not be sufficient. If blast is identified as a *threat* in the *threat* and *risk* assessments, a professional engineer experienced in the design of buildings to mitigate blast effects should be retained. In addition, to allow for partial functioning of building equipment under seismic loading, refer to *Practical Guide to Seismic Restraint*[6], Chapter 16, "Bomb Blast Design."

Strengthening the building envelope to minimize injuries due to glass and other fragments is good practice not only for blasts and seismic occurrences but also for high winds and impact from flying debris in hurricane and other high-wind locations. The use of laminated and tempered glazing should be considered in areas where these conditions occur.

5.4.2.2 Progressive Collapse. For **serious *risk*** and higher, the design professional should avoid designs that facilitate or are vulnerable to progressive collapse. All new facilities should be designed for the loss of a column for one floor above grade at the building perimeter without progressive collapse. This design and analysis requirement for progressive collapse is not solely part of a blast analysis. It is intended to ensure adequate redundant load paths in the structure should damage occur for whatever reason. Design professionals may apply static and/or dynamic methods of analysis to meet this goal. Ultimate load capacities may be assumed in the analyses. ASCE/SEI Standard 7-16, *Minimum Design Loads for Buildings and Other Structures*[7], describes progressive collapse and offers additional guidelines. See Informative Appendix D.

In recognition that a larger-than-designed-for explosive (or other) event may cause a partial collapse of the structure, new facilities with a defined *threat* should be designed with a reasonable probability that, if local damage occurs, the structure will not collapse or be damaged to an extent disproportionate to the original cause of the damage.

In the event of an internal explosion in an uncontrolled public ground floor area, the design should prevent progressive collapse due to the loss of one primary column, or the design professional should show that the proposed design precludes such a loss. That is, if columns are sized, reinforced, or protected so that the *threat* charge will not cause the column to be critically damaged, then progressive collapse calculations are not required for the internal event. For design purposes, assume there is no additional standoff from the column beyond what is permitted by the design. For example, if an explosive event causes the local failure of one column and major collapse within one structural bay, a design that mitigates progressive collapse would preclude the additional loss of primary structural members beyond this localized damage zone (the loss of additional columns, main girders, etc.). This does not preclude the additional loss of secondary structural or nonstructural elements outside the initial zone of localized damage provided the loss of such members is acceptable for that performance level and the loss does not precipitate the onset of progressive collapse.

5.4.2.3 Building Materials. For **moderate *risk*** and higher, special consideration should be given to materials that have inherent ductility and that are better able to respond to load reversals (i.e., cast-in-place reinforced concrete and steel construction). Careful detailing is required for material such as prestressed concrete, precast concrete, and masonry to adequately respond to the design loads. Unreinforced masonry is unacceptable. Prestressed concrete is not very ductile and may not be appropriate where load reversals may occur.

5.4.2.4 Exterior Opaque Walls. Exterior walls should be designed for the actual wind, seismic, and blast forces determined by the *threat* and *risk* assessments. Walls should be capable of withstanding the dynamic reactions from the windows and curtain walls.

Shear walls that are essential to the lateral and vertical load-bearing system, which also function as exterior walls, should be considered primary structures. Exterior shear walls should be designed to resist the actual forces predicted from the *threat* and *risk* assessments. Where exterior walls are not designed for the full design loads, the design professional should give special consideration to construction types that reduce the potential for injury.

5.4.2.5 Exterior Windows and Curtain Walls. Fire safety is an important design consideration for window design and curtain walls. The performance requirements for all security glazing materials proposed for the project should be evaluated. The design professional should also ensure that normal tools carried by firefighters, such as a pick head ax, halligan tool, or similar device, can readily overcome glazing barriers. If the use of more specialized tools, such as a rabbit tool, a k-tool, circular saws, rams, or similar devices is nec-

Table 2 Glazing Protection Levels Based on Fragment Impact Locations

Performance Condition	Protection Level	Hazard Level	Description of Window Glazing Response
1	Safe	None	Glazing does not break. No visible damage to glazing or frame.
2	Very high	None	Glazing cracks but is retained by the frame. Dusting or very small fragments near sill or on floor acceptable.
3a	High	Very low	Glazing cracks. Fragments enter space and land on floor no further than 1 m (3.3 ft) from the window.
3b	High	Low	Glazing cracks. Fragments enter space and land on floor no further than 3 m (10 ft) from the window.
4	Medium	Medium	Glazing cracks. Fragments enter space and land on floor and impact a vertical witness panel at a distance of no more than 3 m (10 ft) from the window at a height no greater than 0.6 m (2 ft) above the floor. Glazing cracks and window system fails catastrophically.
5	Low	High	Fragments enter space impacting a vertical witness panel at a distance of no more than 3 m (10 ft) from the window at a height greater than 0.6 m (2 ft) above the floor.

essary to break through the glazing barrier, or if the glazing itself is *hardened* so that high pressures may not blow out the windows and curtain walls, alternative methods or systems should be designed to ensure that smoke from an incident is not trapped inside the building.

A combination of methods may be used, such as computer programs coupled with test data and recognized dynamic structural analysis techniques, to show either that the glazing survives the specified *threats* or that the postdamage performance of the glazing protects the occupants, as specified in Table 2. When using such methods, use a breakage probability no higher than 750 breaks per 1000 attempts when calculating loads to frames and anchorage.

5.4.2.5.1 Negligible and Minor Risk Levels. Performance Condition 4 or better in Table 2 should be considered.

5.4.2.5.2 Moderate Risk Level. There is no requirement to design windows or curtain walls for specific blast pressure loads. However, design professionals are encouraged to use glazing materials and designs that minimize the potential *risks* for blast or other incidents.

Performance Condition 3 or better in Table 2 should be considered. Preferred systems include the following:

a. Tempered, heat-strengthened, or annealed glass with a security film installed on the interior surface and attached to the frame
b. Laminated tempered, laminated heat-strengthened, or laminated annealed glass
c. Blast curtains
d. Anchored mullions and framing systems

Acceptable systems include the following:

a. Tempered glass
b. Tempered, heat-strengthened, or annealed glass with security film installed on the interior surface (Edge-to-edge, wet-glazed, or daylight installations are acceptable.)
c. Reinforced mullions and framing systems

Unacceptable systems include the following:

a. Untreated monolithic annealed or heat-strengthened glass
b. Wire glass
c. Nonreinforced mullions and framing systems

If used, security film should be a minimum of 0.1 mm (4 mil) thick. When applying antishatter security film, consider that in a blast environment, glazing can induce loads three or more times that of conventional loads onto the frames.

Window and curtain wall frames should be designed so that they do not fail before the glazing under lateral load. Likewise, the anchorage should be stronger than the window or curtain wall frame, and the supporting opaque wall or structure should be stronger than the anchorage. The design strength of a window or curtain wall frame and associated anchorage is related to the breaking strength of the glazing. Tempered glass is roughly four times as strong as annealed glass, and heat-strengthened glass is roughly twice as strong as annealed glass.

5.4.2.5.3 Serious and Critical Risk Levels. Design should be up to the specified load identified in the *threat* and *risk* assessments. Performance Condition 2 or better in Table 2 should be considered. Design for exterior window and curtain wall systems (glazing, frames, anchorage to supporting walls, etc.) should be balanced to mitigate the hazardous effects of flying glazing following an explosive event. The walls, anchorage, and framing should fully develop the capacity of the glazing material selected.

While most test data use glazing framed with a deep bite, this may not be amenable to effective glazing performance or installation. New glazing systems with a 13 mm (0.5 in.) bite can be engineered to meet Performance Condition 2 or better in Table 2 with the application of structural silicone. However, not much information is available on the long-term performance of glazing attached by structural silicone or with anchored security films.

All glazing hazard reduction products for the protection levels in Table 2 require product-specific test results and engineering analyses performed by an independent testing agency.

These tests and analyses should demonstrate the performance of the product under the specified blast loads and state that the product meets or exceeds Performance Condition 2 or better in Table 2.

a. **Window fenestration.** The total fenestration openings are not limited; however, a maximum of 40% per structural bay is a preferred design goal.
b. **Window frames.** The frame system should develop the full capacity of the chosen glazing up to 750 breaks per 1000 attempts and provide the required level of protection without failure. This can be shown through design calculations or approved testing methods.
c. **Anchorage.** The anchorage should remain attached to the walls of the facility during an explosive event without failure. Capacity of the anchorage system can be shown through design calculations or approved tests that demonstrate that failure of the proposed anchorage will not occur and that the required performance level is provided.

Preferred glazing systems include the following:

a. Tempered glass with a security film installed on the interior surface and attached to the frame
b. Laminated tempered, laminated heat-strengthened, or laminated annealed glass
c. Blast curtains
d. Anchored mullions and framing systems

Acceptable systems include monolithic tempered glass with or without security film if the pane is designed to Performance Condition 2 or better in Table 2. Unacceptable systems include untreated monolithic annealed or heat-strengthened glass and wire glass.

In general, thicker antishatter security films provide higher levels of hazard mitigation than thinner films. Film that is 0.18 mm (7 mil) thick, or specially manufactured 0.1 mm (4 mil) thick film, is the minimum necessary to provide hazard mitigation from blast.

In some cases, it may be beneficial and economically feasible to select a glazing system that demonstrates a higher, safer performance condition. Where tests indicate that one design will perform better at significantly higher loads, that design could be given preference.

Where peak pressures acting on the face of the building from the design explosive *threats* can be shown to be below 6.9 kPa (1 psi), the guidelines above may be reduced.

5.4.2.6 Additional Glazing Guidelines. For serious and critical *risk* levels, ballistic resistant windows, if required by the *threat* and *risk* assessments, should meet the requirements of the appropriate UL 752, *Standard for Bullet-Resisting Equipment* [8]. Glass-clad polycarbonate or laminated polycarbonate are two acceptable glazing materials.

Security glazing, if required by the *threat* and *risk* assessments, should meet the requirements of ASTM F1233-08(2013), *Standard Test Method for Security Glazing Materials and Systems* [9] or UL 972, *Standard for Burglary Resisting Glazing Material* [10].

If resistance of window assemblies (excluding glazing) to forced entry is required by the *threat* and *risk* assessments, use ASTM F588, *Standard Test Methods for Measuring the Forced Entry Resistance of Window Assemblies, Excluding Glazing Impact* [11] to select the appropriate grade.

5.4.2.7 Nonwindow Openings to the Exterior. For serious and critical *risk* levels, nonwindow openings, such as mechanical openings and exposed plenums, should be designed to the level of protection required for the exterior wall. Designs should account for potential in-filling of blast overpressures through such openings. The design of structural members and all mechanical system mountings and attachments should be sufficient for these openings to resist these interior fill pressures.

5.4.2.8 Building Openings. Where there is no site perimeter barrier, and where no screening is performed at the perimeter, the exterior of the building is the first line of defense against a wide variety of *threats*, including vandalism, forced entry, winds, and blast.

Depending on the severity of the *threat*, as determined by the *threat* and *risk* assessments, doors, windows, louvers, and other openings may need to be constructed of more robust materials than usual and be firmly anchored in the surrounding construction. This may include forced-entry resistance and ballistic resistance and often consists of construction that enhances protection against storms and floods.

Doors are especially attractive to unauthorized entry, and the door construction and access control hardware should be commensurate with the *threats* identified in the *threat* and *risk* assessments. Doors and other openings should be able to be secured against entry by unauthorized persons. Access control may range from ordinary mechanical locks to highly sophisticated electronic card-key and biometric identification systems.

Building design should consider the number of openings, especially exterior doors. Exterior doors needing the protection discussed above often include the following:

a. Main entrance
b. Secondary entrances
c. Emergency exits
d. Garage entrances
e. Central power and heating/refrigeration plants
f. Generator and switchgear
g. Fire control center
h. Flammable liquids and gases storage
i. Fire and potable water pump rooms
j. Meter rooms
k. Transformer and other electrical rooms
l. Telephone and other communications rooms
m. Utility tunnels

Emergency exits should be alarmed and be secured with self-locking doors that can be opened only from the inside and be consistent with fire and life safety requirements (see NFPA 101, *Life Safety Code*® [12]).

At a location approved by the decision maker, and near entrance doors, a wall-mounted secure container may be used to provide keys and/or card-keys for emergency response personnel to enter the building and areas inside, including mechanical rooms. The secure container should be secured with a high-security key, usually in the possession of emergency response personnel. If a door associated with this system is separate and distinct from other entrance doors, it should be controlled and monitored.

Air intakes should be elevated to reduce blast effects through ductwork and to minimize contamination of the inlet airstream (see Section 5.4.2.11).

Window and louver openings on the ground floor, in area wells, or within easy reach by improvised ladders from the ground or adjacent to low roofs need intrusion detection protection as discussed below.

5.4.2.9 Areaways. All areaways should have gratings secured in place to prevent unauthorized access from the outside. High-security padlocks may be used unless the grating provides emergency egress from below, in which case emergency egress hardware with a hatch should be used.

Areaways should not be used for outdoor air intake to ventilation systems. If an areaway cannot be avoided for other uses, access to the areaway should be prevented by a surrounding fence or other construction preventing insertion of toxic agents into the areaway and/or air intake. For **moderate *risk*** and higher categories, consider including surveillance cameras at areaway entrances.

5.4.2.10 Roof. For **negligible *risk*** and higher:

a. Subject to requirements of fire and life safety codes, consider securing doors to and from rooftops, including mechanical and elevator equipment penthouses and stair towers, against unauthorized access from the roof.
b. Consider protecting outdoor air intake louvers at roof levels from forced and surreptitious entry or from introduction of CBR agents.
c. Consider securing skylights, roof hatches, exhaust fans, and other rooftop items leading to the building interior from forced or surreptitious entry.
d. Emergency antennae should be protected from vandalism or other tampering.

5.4.2.11 Outdoor Air Intake Locations. Outdoor air intakes should be located so that they are protected from external sources of contamination. Standard 62.1 [2] specifies distances from various sources of contamination for **negligible *risk*** and **minor *risk*** facilities.

For **moderate *risk*** and higher, outdoor air intakes should be located away from public accessible areas, preferably at the roof level or at exterior walls of high-rise buildings. Obstructions near the intakes that might conceal a contaminant delivery device need to be minimized. Consider the use of intrusion alarm sensors to monitor the intake areas.

5.4.2.12 Air and Vapor Control. Building envelopes should be designed to minimize air and water vapor infiltration and exfiltration. Building envelope integrity is important for the following reasons: (a) limiting water vapor transport is paramount to reducing the likelihood of mold and mildew, (b) a good thermal envelope is beneficial to interior thermal comfort, and (c) good thermal envelope integrity reduces energy consumption for space conditioning. A building envelope that meets these needs is also likely to provide some reduction in *vulnerability* to *extraordinary incidents* associated with airborne contaminant releases. Building envelopes often allow excessive air and humidity into a building. Tightening the building envelope reduces the entry of contaminants from the outdoors and reduces the amount of outdoor air required to pressurize the building.

Verifying the integrity of the building exterior envelope through testing is essential to ensuring that a new or renovated building envelope will provide a good barrier to heat, air, and water vapor transport. Such airtightness testing is typically performed using fan pressurization techniques as described in ASTM E779, *Standard Test Method for Determining Air Leakage Rate by Fan Pressurization* [13], and in ASTM E1105, *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference* [14].

If building pressurization is being employed as a protective strategy against external releases, then the design needs to consider that successful pressurization will be impacted by exhaust air systems, such as toilet and kitchen exhaust. In practice, the design level of pressurization should be based on the pressures to overcome wind, stack, and exhaust effects. If the existing building envelope is being retained as part of a renovation project, sealing the building envelope to reduce air leakage may also be justified based on energy savings and comfort.

For design of liquid water barriers, water vapor retarders, and air infiltration barriers, see the *ASHRAE Handbook—Fundamentals* [15] and *ASHRAE Handbook—HVAC Applications*[16].

5.4.3 Building Systems. Building systems include the following:

a. HVAC systems
b. Domestic water systems
c. Food preparation systems
d. Communications systems
e. Fire protection systems
f. Exterior security devices and systems
g. Interior security systems

5.4.3.1 HVAC Systems. Natural hazards that impact HVAC systems include flood, smoke from fire, and seismic activity. Other extraordinary accidental impacts include blast from explosion, byproducts of combustion (smoke), utility disruptions, spills of toxic materials, etc. Criminal *threat* conditions that impact HVAC systems include arson, sabotage, vandalism, and cyber attacks. Terrorist *threats* of primary concern are deliberate release of (a) chemical warfare agents, (b) biological warfare agents, (c) radiological agents, and (d) toxic industrial chemicals. Release of these agents may be either internal or external to the building. External releases may occur by direct insertion into the outdoor air intake by remote release of a directed plume from a standoff (i.e., the distance from event to target) directed plume, or by overhead aerial release. These releases may include multiple agents, including smoke, which may need to be addressed based on *risk*. Given the variety of possible methods, *risk* evaluation is especially important prior to implementing systems design.

5.4.3.1.1 HVAC Air Distribution Systems. There are several types of air distribution system that provide for heating, cooling, and ventilating of occupied spaces. Generally, they may be categorized as unitary air-handling units and central air-handling units. Unitary systems are characterized by the need for separate outdoor air supplies, power supplies, water supplies, and drain lines. Central air-handling units deliver air to occupied spaces in either constant-air-volume (CAV) or variable-air-volume (VAV) design. Return air for central air-handling systems may be either ducted or plenum return (or a combination thereof). Unitary systems may or may not have return systems. The limitations of various types of systems that prevent protection against *extraordinary incidents* should be recognized.

VAV systems should be carefully reviewed to ensure that the quantity of outdoor air to pressurize the building, when exhaust systems are operational does not exceed the sum of the minimum air volume settings for the terminal boxes; otherwise, the building or pressure zones may become negatively pressurized to adjacent areas.

Where the *threat* and *risk* assessments indicate the need to provide separate areas within the building to protect building occupants, equipment, materials, etc., then additional pressure zones within the building should be considered.

Separate air distribution systems should be considered for each pressurization zone. As ventilation and exhaust requirements may vary for each floor of similar pressurization requirement within a building, consider a dedicated air-handling unit located on the floor. The relief system, if required, should be dedicated to that floor. Control of the air-handling system and the dampers used to maintain the required space differential pressure should be kept as simple as possible to facilitate good system control and to make the Commissioning Process easier. Test and balance of the air systems and controls are critical in the commissioning of systems, especially in **moderate *risk*** and higher facilities.

5.4.3.1.2 General Design Guidance for Contamination Control. Airborne particulate and gaseous releases impact indoor environment quality and can occur at multiple internal and external locations. The location of contaminant control devices (particle filtration, gaseous adsorption, ultraviolet irradiation, etc.) may be in the occupied space, in the outdoor intake, in the return air, or in the mixed air of the air-handling unit. The environmental conditions (e.g., temperature, relative humidity, and other contaminants) can have significant impact on the performance of these control devices. The design professional should be aware of the pathways of the particulate and gaseous contaminants and the local environmental conditions in order to select appropriate devices compatible with the *threats* and *risks* determined in Section 4.

Although some situations with sufficient warning may warrant shutting down HVAC systems in the event of accidental spills, etc., the impacts of many scenarios may be worsened by such a response. These include proximate external releases where contaminants are immediately drawn into a building, as well as remote releases that have high probability of impact on internal areas. When wind conditions exceed 7 to 9 m/s (15 to 20 mph), a contaminant plume released over a short period of time and directed toward a building flows past the outdoor air intake rapidly. During milder weather conditions, a large percentage of prevailing winds range from 2 to 7/9 m/s (5 to 15/20 mph), but in such cases, fan inertia will draw in contaminants from 30 to 45 m (100 to 150 ft) away even if reaction time is instantaneous. In either case, fan shutdown is counterproductive. When wind conditions are below 2 m/s (5 mph), plume dispersion occurs rapidly, and remote releases are diffused before reaching their target.

Under normal conditions, filtration has been provided to collect large airborne particulate matter that otherwise would lodge within cooling coils or ductwork. In many cases, these particulate filters have been installed in outdoor airstreams ahead of moisture control or in the mixed airstreams ahead of the heating and cooling coils (without other filtration to reduce gaseous contaminants). Hospitals, laboratories, and special processing facilities use enhanced filtration to contain smaller particulate matter down to the microbiological size. (These filters are usually located in the supply airstream, downstream of the heating and cooling coils.) Such enhanced filtration for specialty applications should be considered to address biological and radiological concerns with improved indoor air quality as a byproduct under normal operations. In some HVAC designs (i.e., unitary systems), only outdoor air is filtered while radiators and finned cooling/heating hydronic systems thermally condition indoor areas. In other unitary systems, only minimal filtration (if any) is provided with fan-coil units or newer ceiling suspended heat exchangers. Systems that employ central air-handling units provide continuous filtration of both return air and outdoor air, thereby containing airborne particulate matter that is generated indoors as well as induced with outdoor air. With enhanced filtration, such air-handling units are capable of capturing pathological contaminants that may be accidentally released or intentionally dispersed both internally and externally.

Gas adsorption generally has not been designed into many building HVAC systems, but, rather, installed in specialty process systems and in transportation terminals. Increased concern about chemical terrorist activity has prompted design professionals to consider gas adsorption in conjunction with particulate filtration. Gas phase air cleaners have not attained the same wide level of use and application as particulate filters. Recent ASHRAE standards (Standards 145.1 and 145.2) provide methods of assessment for gas-phase air cleaners. Adsorption can provide gaseous contaminant control and is dependent upon the adsorbent chemistry and the characteristics of the adsorption bed as related to bed depth and dwell time.

Table 4 describes the four grades of carbon, their use, and general specification. Generally, Designations A and T are used for commercial and institutional facilities. Additional information regarding design procedures for gaseous contaminant control for occupied spaces can be found in *ASHRAE Handbook—HVAC Applications* [16], Chapter 46, "Air Cleaners for Gaseous Contaminants."

One of the most powerful benefits of enhanced filtration is that health and life safety is not reduced to being solely dependent on sensor reliability. On the operations and maintenance side, even though added pressure drop involves more fan energy, a simple system without complex sensors and remote fan override circuits may reduce maintenance costs and enhance reliability in critical health and safety HVAC systems.

Table 3 Comparison of MERV Data, Filter Type, and Prior Designations

MERV LEVEL	Dust Spot %	Typical Particulate Filter Type	Removal Efficiency % 0.3 to 1 µm	% 1 to 3 µm	% 3 to 10 µm
1	NA	Low-efficiency fiberglass and synthetic media disposable panels, cleanable filters, and electrostatic charged media panels	Efficiency is too low to be applicable to ASHRAE Standard 52.2 [17] determination.		
2	NA				
3	NA				
4	NA				
5	NA	Pleated filters, cartridge/cube filters, and disposable multidensity synthetic link panels			20 to 35
6	NA				36 to 50
7	25% to 30%				50 to 70
8	30% to 35%				>70
9	40% to 45%	Enhanced media pleated filters, bag filters of either fiberglass or synthetic media, rigid box filters using lofted or paper media		>50	>85
10	50% to 55%			50 to 65	>85
11	60% to 65%			65 to 80	>85
12	70% to 75%			>80	>90
13	80% to 85%	Bag filters, rigid box filters, minipleat cartridge filters	>75	>90	>90
14	90% to 95%		75 to 85	>90	>90
15	>95%		85 to 95	>90	>90
16	98%		>95	>95	>95
The following classes are determined by methodology different than ASHRAE Standard 52.2 [17]:					
17	NA	HEPA/ULPA filters evaluated using IEST-RP-CC007.1[18]. Types A through D yield efficiencies at 0.3 µm and Type F @ 0.1 µm	99.97% IEST Type A		
18	NA		99.99% IEST Type C		
19	NA		99.999% IEST Type D		
20	NA		>99.999% IEST Type F		

When designing new facilities or retrofitting existing facilities, *dedicated outdoor air*-handling units together with recirculation air-handling units should be considered for all *risk* categories. Tables 3 and 4 contain particulate filter and adsorption technical data that should be used as design guidelines for new and existing facilities. Existing systems typically are oversized, and enhanced filtration often can be accommodated by slight sheave and motor adjustments without requiring larger fans, especially if outdoor air requirements are reduced with gas adsorption filters. When a conflict arises with codes, a variance may be required. New systems should consider regular particulate and gas adsorption prefiltration in the outdoor air handler, with regular frequent filter maintenance, preconditioning, and dehumidification (i.e., 40% to 60% rh). Recirculation air-handling units should be provided in each pressure zone with enhanced filtration at MERV 13 level or higher for **moderate *risk*** and lower categories and at the MERV 17 level or higher for **serious *risk*** and **critical *risk*** to protect against biological contaminants. If the *risk* assessment dictates a lower level of particulate filtration, then more air changes per hour are required to achieve the same protection (i.e., higher fan speeds and energy consumption) or more filters should be purchased in larger air handlers, or longer exposure time should be accepted.

Various engineering approaches can be used for health and safety and improved indoor air quality. U.S. embassies and consulates were able to incorporate such enhanced filtration into air handlers, which required (with maintenance space) 6% of the gross floor area. Only 1% of this gross floor space was necessary for the prefilter, HEPA, and HEGA filters to protect against CBR *threats*.

In addition to chemical and biological contaminants, radiological contaminants should be considered. The increase in the scientific and warfare applications of radionuclides has led to the greater availability of these compounds. Additional sources of radionuclides include health-care centers, which routinely use radionuclides in x-rays and cancer treatment. Finally, the collapse of the Soviet Union with its vast nuclear production complex has raised the fears of stolen radionuclides for use in an adversarial or threatening matter.

Table 4 Comparison of Types of Carbon Filters

Designation	Description	Specification
A	Activated 8×16 mesh carbon is used to adsorb heavy solvents, elemental iodine, and most odors.	The activated carbon shall be coconut shell base, 8×16 mesh and shall have a minimum carbon tetrachloride activity of 60% when tested in accordance with ASTM D3467 [19]. The carbon shall meet the base carbon requirements for nuclear grade carbon.
N	Nuclear grade 8×16 mesh carbon is specially impregnated activated carbon used to adsorb organic radio iodides.	The nuclear grade carbon shall be coconut shell base, 8×16 mesh that meets the requirements of ASME N509 [20], Chapter 5.2.
W	Whetlerized 12×30 mesh carbon is specially impregnated activated carbon used to adsorb toxic warfare gases.	The activated carbon shall be a specially impregnated coal base that meets the requirements of Military Standard MIL-C0013724D [21].
T	ASZM-TEDA (cooperite) 12×30 mesh carbon is used to adsorb toxic warfare gases. Performs similar to whetlerite. Impregnants do not contain chromium.	The activated carbon shall be a specially impregnated coal base that meets the requirements of EA-DTL-1704 [22].

5.4.3.1.3 Access to Air-Handling Equipment, Ductwork, Building Automation Systems, and Control Systems. Access to air distribution equipment, ductwork, building automation systems, and control systems should be controlled and limited to authorized maintenance staff only. Rooms housing such equipment should be locked and an effective key control system implemented. Access to roof areas where outdoor air intakes, exhaust fans, and other essential mechanical equipment are located should be similarly controlled (see Section 5.4.2.5).

For facilities of **moderate *risk*** and higher, ductwork should be routed to avoid unauthorized access. Ductwork entering lobby areas that are susceptible to higher *risk* may require security grills to prevent entry by attackers. Public areas of the building should be provided with separate air distribution systems, where practical, and return air ducted back to its air-handling unit or exhausted outside.

5.4.3.1.4 HVAC Response and Control Sequences. Integrating the control sequences of HVAC systems for normal and extraordinary periods of operation is a critical design issue. Fundamentally, the issue is one of priority control. Given the variations in extraordinary conditions that can occur, a priority scheme should be determined to change from normal control sequences in order to respond to fire, smoke, floods, seismic events, wind, and/or accidental and intentional releases of contaminants. The following guidance is provided regarding control sequence responses to extraordinary releases of airborne contaminants (e.g., natural or accidental releases of particulate or gaseous contaminants, or intentional releases of CBR agents), but the priority of control should be decided based on the relative *risk* assessment at the particular facility. The prioritization schedule matched to incidents should be maintained in an operations manual and/or clearly displayed for operating personnel and emergency response personnel (see Sections 6.5 and 6.6).

For facilities that have been designed without enhanced contamination control features (Section 5.4.3.1.2), consideration should be given to alternative control sequences in which the HVAC systems are shut down in response to outside or internal releases. If this alternative is chosen:

a. It should be noted that shutting down the HVAC systems as a general response control strategy is likely to exacerbate exposure to the releases of the contaminants.
b. Shutdown switches should be readily accessible to emergency response personnel and accountable building occupants.
c. Rigorous training should be provided to the accountable occupants to ensure that they are aware of pressure imbalances that might be created in adjacent zones due to the switching alternatives.
d. A single tamper-resistant switch to shut off all fans and air-handling systems, including all outdoor air fans and louvers and exhaust fans and louvers, should be considered.
e. The switch should be clearly marked, and instructions should be posted near the switch. An easily removed cover to prevent inadvertent shutdown should be considered.
f. These switching alternatives must not compromise the requirements of the fire, smoke, and other life-safety requirements of the building.

For buildings that have been designed with enhanced contamination control (see Section 5.4.3.1.2), the transfer from the normal to response (i.e., emergency) mode of operation will be dependent on both the characteristics of the agent and the location of release.

a. For an internal release, the HVAC systems should respond to a manual signal or automatic signals by isolating the zone(s) of release, impeding the migration or transport of the contaminant (e.g., CBR agent) to other zones, and by removing the agent with purging or with filtration/air-cleaning components in the HVAC system.
b. For an external release of a known contaminant or agent, some of the HVAC systems should continue to run. Options

that should be considered also include closing the outdoor air dampers that have been directly attacked and opening the outdoor air dampers that have not been attacked in order to maintain the zone pressures.

c. An alarm/notification system should be considered for all extraordinary modes of operation. There are presently no known CBR monitors that can provide the information quickly enough to protect occupants of a building. Even if monitors were available, they would have to be located in every zone of the building and connected to a central monitoring system.
d. The response time to maximize the contaminant removal with purging, outdoor, recirculation, and exhaust air rates should be considered. Moreover, the response times to pressurize or depressurize the affected zones should be considered.
e. It should be noted that for this response mode to function, a coordinated control sequence is required to close certain dampers and shut down certain fans while opening other dampers and running other fans. These requirements must be determined on a site-specific basis by the decision maker and the design professional.

5.4.3.2 Food Services Systems. Areas where food is received, prepared, and distributed should be designed following approved sanitation guidelines. These guidelines are necessary to minimize the formation and growth of bacteria. Typical sanitation guidelines address wall construction, floor-to-wall juncture, floor construction, and utility installation.

The walls should be constructed of a smooth and impervious material that is easily washable and that will inhibit bacteria growth.

The floor and wall junction should be a round radius curve that is easily cleaned and that will not harbor dirt in the corners.

The floor in a washable area should have a pitch of at least 1 cm per meter (1/8 in. per foot) to the drain to reduce the possibility of standing water puddles. All piping and fixtures should either be fastened tight to the wall surface and caulked or set 2.54 cm (1 in.) off the wall so as to be easily cleaned, thereby reducing the harboring of bacteria.

Bar joist construction and other exposed building components are not recommended above open food because dirt can collect on the structure and drop into the food.

The areas should be designed so that they are secured when the public is not being served. The areas should be accessible only to approved individuals to prevent tampering during off-hours.

5.4.3.3 Domestic Water Systems. The requirement for the water system serving the building is to protect the public water system, the building occupants, and guests. A public water system is defined as any water system serving at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year [23].

For **moderate *risk*** and lower, protection of the building water system includes protection against cross contamination, compliance with applicable health and plumbing codes, and the requirements of the water supplier. However, the *threat* and *risk* assessments should be reviewed to determine if specific additional action is required other than prevention of unauthorized access and compliance with the health and plumbing codes and the local water supplier requirements.

For **serious *risk*** and higher, the storage of potable bottled water or alternate secure water supplies (from a well or additional on-site storage) should be evaluated based on the duration of the *extraordinary incident*. This information should be provided to the new facility or rehabitation of an existing facility to evaluate the options and provide a design that protects the building water system and prevents contamination of the public water system from this facility. Additional treatment should also be evaluated of on-site processing of nonpotable water into potable water, and any testing and/or monitoring required to meet state and local codes. The use of bottled water, especially for possible shelter-in-place, should consider shelf life issues and rotation of stock.

For **all *risk* levels**, nonpotable water should be prevented from entering the public water system in compliance with the health and plumbing codes.

5.4.3.4 Fire Protection Systems. Fire protection systems consist of suppression and detection systems. Both can be automatic and manual. These systems are important in the overall protection of the building and safety of the occupants. Both suppression and detection systems are dependent on other building systems, such as the domestic water system and the electrical power supply (see Section 5.3 for details regarding the protection of these services).

5.4.3.4.1 Water Supply. Water supplies for fire protection can be public, private, or a combination of both. Water supplies are addressed in Section 5.3.4 and should be protected in accordance with this section. In addition to the requirements of Section 5.3.4, for **serious *risk*** or higher, consideration should be given to further protection of the water tank from possible sabotage or terrorist attack. Consideration should be given to locating the water tank underground, inside the building, or on top of buildings.

5.4.3.4.2 Fire Pumps. Where the fire protection system pressure is not adequate, a fire pump is necessary to boost the pressure. Fire pumps, when provided, are a critical component of the fire protection system to ensure the system will function as designed. Any attack on or failure of the fire pump will have an adverse effect on the success of fire suppression. For **all *risk* levels**, fire pumps should be protected to ensure the pump will run when needed. This should include locating the pump room in areas that are controlled against unauthorized access, ensuring that there is a reliable source of power and backup power for electric driven pumps and an adequate fuel supply for diesel or natural gas driven fire pumps.

5.4.3.4.3 Piping/Distribution System. An attack and breech of the system piping will lead to a failure of the fire protection system. The incoming underground piping can be protected by access control, but much of the piping is either exposed to the public or only slightly protected by ceiling tiles or finished ceilings.

Valves are also a critical component to system operation. Closing riser valves or main valves will impair all of or part of the sprinkler system. Riser valves are located in the sprinkler room, which should be controlled against unauthorized access.

Sprinkler main valves are often exposed and visible in stairwells and other public spaces.

For **moderate *risk*** and lower, access to the sprinkler system riser and valves should be through areas that are controlled against unauthorized access. This can be accomplished by lockable doors or locating risers in areas that are not accessible by the public. Valves should be either electrically supervised or locked or chained open.

For **serious *risk*** or higher, access to the sprinkler system riser and valves should be located in areas that are monitored by closed-circuit television (CCTV) and controlled against unauthorized access. Valves should be electrically supervised and locked or chained open. When the sprinkler valve room and risers are located in close proximity to areas subject to blasts, such as lobbies or loading docks, consideration should be given to blast *hardening* the space.

5.4.3.4.4 Standpipes. Standpipes are critical for manual fire suppression activity. Standpipes are located in the stairwells and are available for fire department use. The standpipes are vulnerable to attack if they are exposed to the public.

For **moderate *risk*** or lower, the piping should be protected from mechanical damage, and the connections should be protected with metal caps. Valves should be electrically supervised *or* locked or chained open.

For **serious *risk*** or higher, the piping should be protected from mechanical damage, and the connections should be protected with metal caps. Valves should be electrically supervised *and* locked or chained open.

5.4.3.4.5 Fire Alarm and Detection Systems. Fire alarm systems consist of automatic detection of fire, smoke, and heat; manual pull stations; audio and visual notification appliances (e.g., speakers, bells, and strobes); and interconnections to elevators and fire suppression system components. The fire alarm and detection system is most vulnerable at the fire alarm control panel. Damaging the control panel or interrupting the primary and emergency power supply can disable the entire system. For **moderate *risk*** or higher, mass notification systems should be considered.

For **moderate *risk*** or lower, the fire alarm control panel should be located in an area that is controlled against unauthorized access. The power supply for the control panel should be protected from attack (see Section 5.3.3).

For **serious *risk*** or higher, the fire alarm control panel should be located in an area that is controlled against unauthorized access and monitored. The power supply for the control panel should be protected from attack (see Section 5.3.3). For redundancy, consideration should be given to remote annunciator panels at strategic locations. See Informative Appendix D.

5.4.3.5 Communication Systems. Building communications systems are an essential part of the building protection system. The ability to establish two-way voice communications with building occupants in an emergency allows building security or operations staff to better understand what is happening in the building, and it allows the building staff to communicate clear directions to the occupants (e.g., orders to evacuate versus to seek shelter inside).

Two-way communications should be installed adjacent to stairwells, *areas of refuge*, and other strategic locations. A control station should have supervisory override to mitigate confusing interruptions from nonthreatened areas.

5.4.3.6 Security Systems, Interior and Exterior. Intrusion detection may be added to secure openings, to notify response personnel, and to document attempted entry. Detection devices range from relatively simple electric contacts to vibration-sensing devices on window glass.

Intrusion detection usually assumes some type of response to interdict the attempted entry, such as by law enforcement officials or facility guards. The time for response determines the degree of resistance to forced and surreptitious entry. Some products are rated by the protection time (15 minutes, 1 hour, etc.). Particular assemblies are designed to resist various types of attempted breach (hand tools, machine tools, lock picks, etc.).

Surveillance of the building exterior by CCTV and roving guard personnel may be a deterrent and provide advance warning of an incident to response personnel. Placement of surveillance cameras and use of pan, zoom, and other technologies will enhance the effectiveness of the surveillance system.

Surveillance systems should be coordinated with lighting to provide useful coverage, to avoid "blinding" cameras, and to allow aesthetically acceptable building exteriors. Landscaping close to the building perimeter should be designed to avoid areas of concealment.

Design of the facility for monitoring alarms, CCTV and other security systems, and training of personnel is as important as the design of the systems themselves.

5.4.4 Building Core Areas

5.4.4.1 Core Areas. Core areas of facilities include functional and service areas and various types of public occupancies. Building functional areas and service areas take many forms: public lobbies, mail service, shipping and receiving security, delivery service, parking facilities, etc.

5.4.4.2 Public Lobbies. Public lobbies are often the focus of *extraordinary incidents* involving criminal and terrorist incidents. Lobbies should be designed to respond to the *threats* identified in the *threat* and *risk* assessments. This includes, but is not limited to, forced-entry resistance, ballistic resistance, blast *hardening*, and isolation of lobby air systems from other building systems.

Consideration should be given to locating the delivery and receiving areas, mail rooms, and similar spaces remotely and separately from the public lobby. However, in some cases, these remote locations may not be practical or cost-effective.

For **moderate *risk*** and higher, these and other areas within a building, such as lobby and reception areas and loading docks, that are especially subject to the internal release of an agent, should be provided with dedicated outdoor ventilation and exhaust air-handling systems; should be designed and constructed to provide fire, smoke, and particulate separation from other spaces; and should be kept at a negative pressure with respect to the surrounding internal zones. Where possible, locate delivery and receiving areas, mail rooms, and similar spaces on the first floor with a direct emergency exit.

Any access control, *hardening*, or other security measures should permit emergency evacuation of the building. Where a public lobby may be the scene of violence, fire, smoke, or other toxic agents, primary egress should not be through the lobby, but through egress routes that discharge to the exterior, away from the main entrance.

Vital building systems such as electrical, communications, and fire protection risers should be in spaces away from the lobby or sufficiently hardened to prevent breach under the *threats* identified by the *threat* and *risk* assessments.

Building structural members should be protected against blast in lobby areas.

Doors into the public lobby may be controlled and monitored.

5.4.4.3 Security Guard Stations. In facilities where screening of persons entering the building is not performed at the site perimeter, the main public lobby may be provided with a security guard station with control of all entrance control devices.

If required by the *threats* identified in the *threat* and *risk* assessments, the security guard station may be fully enclosed with UL-rated ballistic construction and forced-entry construction, including partitions, doors, glazed openings, teller windows, and transaction trays, if any.

Access to the guard station should be from behind the enclosure of the lobby and should be of forced-entry construction. Doors to the guard station should be controlled and monitored.

The building's Security Control Center (SCC) containing monitoring devices, etc., and other security personnel, may be collocated with the security guard station in the main public lobby. Doors to the SCC should be controlled and monitored.

In small facilities, the SCC may be a part of the security guard station itself.

Screening devices, such as x-ray and magnetometers, if provide, should be operated by other guard personnel and monitored from within the enclosed security guard station.

CCTV cameras may be provided to permit the guards within the enclosed station to see any areas of approach to the exterior entrances to the lobby, the screening operations within the lobby, and any other areas of the lobby and related adjacent spaces, such as emergency egress stairs discharging into the lobby.

Lobby and guard station lighting should be designed to enhance the guards' views of lobby operations and to avoid interfering reflections in transparent materials.

Access to the facility from the lobby should be through doors controlled and monitored by the guard in the enclosed guard station.

Other entrances to the building should be for use by employees only and should be as few as possible.

Where such entrances have sufficiently heavy traffic, as in some campuses where buildings are accessed from multiple directions, the secondary lobby may warrant the same strategic approach as the main lobby.

Doors should be controlled and monitored.

5.4.4.4 Loading Docks. Loading docks should be designed to respond to the *threats* identified in the *threat* and *risk* assessments. Appropriate measures should include, but not be limited to, blast *hardening* loading dock construction and protecting building structure and construction surrounding the loading and receiving area from the effects of blast from a blast intensity determined by the *threat* and *risk* assessments. Consideration should also be given to isolation of loading dock air systems from other building systems.

Vital building systems, such as electrical, communications, and fire protection risers, should be in spaces located away from the loading dock or sufficiently hardened to prevent breach under the *threats* identified by the *threat* and *risk* assessments.

The transport of loading dock air to other portions of the building should be minimized through pressure control using exhaust ventilation or other means.

Pedestrian doors, stairs, and ramps associated with loading docks should be restricted to authorized personnel and be separated from the loading platform by not less than 1.2 m (4 ft) to discourage bypassing the entry door controls through the loading platform and other doors.

Pedestrian doors should be controlled and monitored. Dock lift controls should be secured to prevent unauthorized use for entry.

All loading dock areas, including the service yard, gate, and various containers, should be included in the facility's CCTV surveillance.

Where feasible, if a second guard post is provided for a building, it should be located where the loading dock and associated doors can be seen and door status and other access control devices monitored by the guard. The guards' office may be near the loading dock supervisor or manager, but the supervisor or manager should not be assumed to be performing guard duties. Doors to the guard booth should be controlled and monitored.

Loading docks should be served from service yards enclosed by a secure fence or wall and power-operated sliding gate, similar to the site perimeter barrier described above, and controlled by card access device and/or remote release and operation by a guard with intercom and CCTV ID.

Trash, recyclables, medical-pathological waste and other containers, compactors, and other similar equipment should be located within the enclosed service yard and placed under CCTV surveillance.

5.4.4.5 Mail Rooms. Mail rooms should be designed to respond to the *threats* identified in the *threat* and *risk* assessments. Appropriate measures should include, but not be limited to, blast *hardening* mail room construction and building structure in the vicinity of the mail room to a blast intensity identified in the *threat* and *risk* assessments. Mail room air exhaust should be directed outside, away from intakes, occupied areas, or egress routes.

Vital building systems such as electrical, communications, and fire protection risers should be in spaces away from the mail room or sufficiently hardened to prevent breach under the *threats* identified by the *threat* and *risk* assessments.

Air handlers and exhaust fans serving mail rooms should not serve other parts of the building.

Entrances to the mail room from the exterior, if any, should be controlled and monitored.

Doors to the interior of a building from a mail room accessible from the exterior should be controlled and monitored.

5.4.4.6 Storage Areas. Storage areas include equipment, expendable supplies, etc. (see below for specialized storage).

All storage rooms, including those entered from exterior or interior, should be controlled and, in **moderate *risk*** and higher facilities, monitored.

Storage for bottled gases, liquids, flammables, pressurized containers, fuel tanks, and other hazardous products, except where more stringent requirements apply as provided by codes, regulations, or statements elsewhere in these guidelines, should be as follows:

a. Storage should be enclosed in rated forced-entry construction, including doors, frames, and associated hardware.
b. Storage room doors, including those entered from exterior or interior, should be controlled and, in **moderate *risk*** and higher facilities, monitored.
c. Storage rooms should generally open to the exterior enclosed service yard or a similarly protected area.

5.4.4.7 Passenger Elevators. Elevators in buildings of **moderate *risk*** and higher, where screening is conducted in the building entrance lobby, should not open directly to the main public lobby but to a separate lobby and, when applicable, beyond the control door leading out of the lobby after any screening area.

An elevator floor position display should be provided in the Fire Control Center and in the enclosed guard station, where available.

Control of elevator access to any restricted or controlled access floors and interstitial mechanical equipment space may be by key or card reader/device in the elevator cab.

Where elevators open directly to a restricted area, the entrance should be monitored by a CCTV camera in the space looking at the entrance.

Access to elevator equipment rooms, including machine rooms and controls, should be controlled and, in facilities of **moderate *risk***, monitored.

5.4.4.8 Emergency Stairs. If reentry to the floor via stairs is required by code because the stairs are not considered a safe haven, consideration should be given to a safe haven such as a corridor or vestibule that does not permit uncontrolled entry to the restricted area of the floor.

The door from the safe haven area to the restricted, controlled access, or interstitial floor should be controlled and monitored.

Where a stairwell opens directly to a restricted area, such as described above, the door should be monitored by a CCTV camera in the space looking at the door. See above for doors from the stairs to the exterior.

If a stairwell opens directly to a restricted, controlled access, or interstitial mechanical equipment floor, the stair door should be controlled and, in facilities of **moderate *risk*** and higher, monitored.

Stairwells should be designed in accordance with the requirements of the applicable building and fire/life safety codes. For **serious *risk*** and higher, stairwells should be pressurized to a minimum of 12.4 Pa (0.05 in. of water) [24] during occupancy with filtration in accordance with Section 5.4.3.1.2.

5.4.4.9 Equipment Rooms. Building equipment rooms include spaces housing the following:

a. Main electrical switchgear and panels
b. Electrical branch distribution panels
c. Transformers
d. Uninterruptible power supply (UPS)
e. Transient suppression equipment
f. Emergency generators and transfer switches
g. Main telephone service
h. Telephone branch distribution panels
i. LAN servers and distribution panels
j. Security systems panels
k. Main control valves
l. Fire pumps
m. Filters and air purification equipment
n. HVAC controls and monitoring equipment
o. Panel rooms for fire alarm control, smoke control, and emergency notification systems

Building systems and their location and protection should be designed to respond to the *threats* identified in the *threat* and *risk* assessments.

Access to all spaces housing the building systems should be controlled and monitored.

Where approved by the decision maker, the lockset may be provided with a high-security key to bypass any card-reader activated access.

Where building systems are centralized in a central mechanical plant, including heating and refrigeration equipment, the access should be controlled and monitored.

5.4.4.10 Food Preparation, Storage, and Dining Facilities. Some facilities include food preparation, storage, serving, and dining services that may be vital to maintain in safe operation under conditions of *extraordinary incidents*, including natural disasters and terrorist attacks. Under routine operations, maintaining safety and sanitation in the storage and handling of foods, plus guarding against theft of supplies and cash, may be the most important objectives. Guarding against intentional contamination of food and water and ensuring adequate supplies, preparation, and distribution under adverse conditions in an emergency situation may also be an objective for certain facilities.

With regard to public access to and from the serving and dining areas:

a. Access should be able to be secured after hours.
b. Access areas should be located in clear view of cashier.
c. Access areas should be under CCTV surveillance.

With regard to food preparation and storage areas:

a. Access to all storage rooms should be controlled and monitored during after hours.
b. A safe for cash should be provided in a lockable room with intrusion detection.

Loading docks for food preparation areas should be constructed and controlled as provided for other loading docks described above.

Areas where food is received, prepared, and distributed should be designed following applicable sanitation guidelines. The areas should be designed so that they are secured when the public is not being served. The areas should be accessible only to authorized individuals to prevent tampering.

All ice-making equipment and storage facilities should have controlled access.

5.4.4.11 Child-Care Centers. Child-care centers may be subject to the provisions of licensure codes and regulations.

Public entrances to child-care centers, including the main entrance and secondary entrances, should be controlled and monitored. Doors should be provided with an intercom to the reception desk with remote access from the desk.

Emergency egress doors from child-care centers should be controlled and monitored. Consider a 2.4 m (8 ft) high fence around all outdoor play and recreation areas with CCTV coverage of the entire area.

Location of the child-care services within the building should be easily accessible for building and emergency personnel, yet be secure from outside intruders.

5.4.4.12 Areas of Refuge, Shelter-in-Place, or Safe Areas. *Areas of refuge*, shelter-in-place, or safe areas should be designed into facilities where evacuation is not a safe option. These areas should be designed for maintaining a predetermined number of people for a specified length of time. For CBR protection, the areas should have an isolated HVAC system that allows them to be maintained at a higher pressure, compared to adjacent spaces, using filtered air, as described in Section 5.4.3.1.2. The areas should be appropriately designed to meet water, food, and sanitation needs as well as temperature, humidity control, and air quality control.

5.5 Building Occupancy Types. This guideline addresses only some of the more common types of occupancy found in buildings. Specialized safety and security needs for other occupancies or building types are beyond the scope of this document and are often addressed by corporate policies, industry guidelines, and some regulations and ordinances. Although multihazard design for most building types is rare and mostly found in FEMA publications, physical security guidance is available in NFPA 730, *Guide for Premises Security*[25] and its companion document NFPA 731, *Standard for the Installation of Electronic Premises Security Systems*[26].

5.5.1 Offices. Office spaces requiring locks should use mortised locksets with high-security cylinders and keys provided and distribution controlled by the owner or management, master keyed as directed or approved by the owner or tenant. See Informative Appendix D.

5.5.2 Patient Care. In addition to meeting the requirements of AIA's *Guidelines for Construction and Equipment of Hospitals and Medical Facilities*[27], Health Insurance Portability and Accountability Act of 1996 (HIPAA), and any other applicable codes and regulations, the patient care areas should have the following security features.

Planning of patient care areas and the access corridors, elevators, and stairways to them should allow maximum visual observation of patients and visitors by patient care or other staff.

Access to nonpatient care areas should be secured as provided elsewhere in these guidelines with the objective of restricting patients and visitors from all nonpatient care functions and of controlling rights of access to authorized personnel authorized by the appropriate entity.

Doors to psychiatric units or other units where patients may be restrained or restricted in their movements from other parts of the building, including emergency stairs and other corridors, should be controlled and monitored with CCTV and other monitors at the nurses' station.

Emergency egress doors from patient care areas should be controlled and monitored and should have motion-activated CCTV camera coverage of the egress side of the door, with all device monitors at the nurses' station for the patient care area served by the egress door.

Patient food preparation, holding, and serving rooms should be controlled and monitored.

Spaces containing patient records or patient information of any kind, such as medical records rooms, x-ray and other images file rooms, file servers, etc. (other than computer terminals at nurses' stations) should be enclosed by rated forced-entry resistant construction, and access should be controlled and monitored.

Nurses' stations and personnel controlling access to patient records should be provided with covert duress alarms to the nearest station of security personnel.

Adequate amounts of first-aid supplies should be present to handle injuries. The supplies should be located strategically so that individuals in all sections of the building can readily receive treatment. A core group of the staff should receive adequate training to administer first aid.

5.5.3 Libraries, Archives, and Cultural Resources. Entrances to archival storage spaces, including book stacks, computer mainframes, and valuable or historical records and collections, should be controlled and monitored. If the entrance also serves as a main entrance to a building, walk-through metal detector and x-ray screening and other features needed for a main entrance lobby may be required.

Where the entrance is for public visitors, lockers for outer garments and parcels should be provided to minimize bringing personal belongings into reading rooms, etc.

Emergency egress doors from archival storage spaces and from reading rooms and other areas used by visitors to the facility should be controlled and monitored and should have motion-activated CCTV camera coverage of the egress side of the door, with all device monitors in a central location within the archival or library area.

Reading rooms, computer terminal areas, and other areas used by visitors to the archival or library area, with the exception of public restrooms, should be monitored by CCTV cameras with sufficient coverage to be able to observe illicit activities, such as defacing or removal of archival or library material. Monitors should be placed at a central location within the archival or library area.

Librarians and archival personnel controlling access to archival storage spaces and at circulation and reference desks should be provided with covert duress alarms connected to the nearest security personnel station.

Exits from reading rooms and other areas used by the public to access archival material should have provisions for inspection of parcels, including x-ray equipment to screen for stolen archival material.

Archives for rare and valuable artifacts and documents should be provided with motion detectors for after-hours monitoring by security personnel.

5.5.4 Banking and Credit Unions. Teller spaces should meet the requirements of UL 752, *Standard for Bullet-Resisting Equipment* [8] for ballistic resistance from the customer side, including transaction windows, partitions, and doors. Each teller position should have a covert duress alarm to the nearest facility security station.

CCTV coverage should be provided of all public areas, including ATMs, the teller line, and vault areas, and should be monitored by the nearest facility security station. Consider the following for nonpublic areas of banks and credit unions:

a. These areas should be controlled and monitored.
b. These areas should be enclosed by forced-entry resistant construction, including partitions, doors, and windows, rated in accordance with response time.
c. Back-of-house areas should be provided with intrusion detection devices monitored at the nearest security personnel station.
d. Vault areas should be protected with one-hour vault construction, including having a vault door and frame with intrusion detection inside and CCTV coverage of the vault door outside the vault.

6. OPERATION AND MAINTENANCE OF BUILDINGS

6.1 Commissioning. Commissioning and recommissioning, as described in ASHRAE Guideline 1.1, *HVAC&R Technical Requirements for the Commissioning Process* [28] and in ASHRAE Guideline 0, *The Commissioning Process* [29], should be an integral part of the *risk* management process. The Commissioning Process (Cx) should be augmented by procedures [30] that define specific performance criteria that demonstrate that the building and its systems are performing as intended under normal conditions and are likely to respond to *extraordinary incidents* consistent with the accepted level of *vulnerability*, as determined in the *risk* assessment (Section 4).

ASHRAE Standard 62.1 [2] also contains a number of requirements for system start-up and commissioning that need to be addressed in all buildings, regardless of *risk* categories.

6.2 Documentation. Complete documentation of the building systems, their design, their operations and maintenance (O&M) procedures, and commissioning documentation should be available and accessible on site. ASHARE Standard 62.1 [2] contains requirements for such documentation. For facilities of **moderate *risk*** and higher, these documents should be considered sensitive information and restricted to limited access.

Preparedness to a *threat* requires documentation of procedures, activities, and responsibilities before, during, and after an emergency. Up-to-date as-built drawings should be kept on site and available to the emergency response personnel. This should include, but not be limited to, floor plans, flow diagrams, control diagrams, and all O&M manuals.

6.2.1 Emergency Action Plans. An emergency response plan should include the responsibilities and duties for all occupants and tenants/employees. This plan should be given wide dissemination among the building occupants and tenants/employees to ensure each has a thorough understanding of their duties and responsibilities. This plan should be developed in coordination with emergency response personnel, as well as people familiar with the protective measures and other design and construction features of the building. The operation of the various systems, including the HVAC systems, alarm and notification systems, building evacuation, and similar procedures, should be included. The emergency plan should also address the conditions under which the building should be evacuated and the conditions under which the occupants should remain within the building or move to designated areas within the building. The emergency plan should consider capabilities of the building occupants and tenants/employees. Anyone assigned responsibilities should be trained to carry out their duties.

6.3 Public Address System. A public address or similar mass notification system should be installed and kept in operating condition in accordance with NFPA 72, *National Fire Alarm Code*®[31].

6.4 Site and Building Security

6.4.1 Personnel. Concentric rings of protection should be developed and maintained. See NFPA 730, *Guide for Premises Security*® [25].

6.4.2 Vehicle Access. Incoming and outgoing vehicles and delivery trucks within the property should be inspected for unusual cargo or activity. Unscheduled deliveries should be held outside the building property, pending verification of shipper and cargo by recipient.

6.4.3 Storage Security

6.4.3.1 Storage Areas. Storage areas are often closets, cabinets, and basement areas that are not readily noticed by building occupants. Hazardous materials or explosives can be hidden in these areas for later use without alarming the building staff. The building's own supply of volatile or hazardous materials can also be used and should therefore be secured.

6.4.3.2 Controlled Access of Storage Areas. Controlled access should be maintained for all sensitive product and ingredient storage areas. An access log should be maintained. Security inspection of all storage facilities (including temporary storage vehicles) should be performed regularly and the results logged.

6.4.3.3 Inventory of Hazardous Chemicals. A regular inventory of hazardous chemicals or other products should be made, and all discrepancies should be investigated immediately. The frequency of inventory checking should be dependent on the *risk* involved.

6.4.4 Food Service Security

6.4.4.1 General. Those facilities where food is served depend on frequent deliveries and on utilities for refrigeration and preparation. Thus, food production and service can be compromised by the inability to deliver supplies or by the lack of utilities. Increased on-site food processing and storage along with alternate utilities can reduce the dependency on deliveries and external utilities.

6.4.4.2 Food Security Management. A food security management team and a food security management coordinator should be identified for each building. Each member should be assigned clear responsibilities. Members of the food security management team should be trained in all provisions of the plan with drills conducted periodically. The plan should be reviewed and revised as needed.

6.4.4.3 Food Security Plan. A food security plan using established *risk* management principles should be developed and implemented. The plan should include procedures for handling *threats* and actual cases of product tampering.

6.4.4.4 Product Tampering Corrective Action. Corrective action taken in all cases of product tampering should ensure that adulterated or potentially injurious products are not released for consumption.

6.4.4.5 Product Recall. The plan should include the immediate containment or recall of adulterated products from trade and consumer channels. Safe handling and disposal of products contaminated with chemical or biological agents should also be included in the plan.

6.4.4.6 Laboratory Assistance of Investigation of Tampering Incidents. A relationship should be established with appropriate analytical laboratories for possible assistance in the investigation of food or product tampering incidents.

6.4.4.7 Notification of Appropriate Personnel. The plan should detail procedures for notifying appropriate law enforcement and public health officials when a food security *threat* is received or when evidence of actual product tampering is observed. All personnel should be encouraged to report any sign of possible product tampering or break in the food security system. All *threats* and incidents of intentional food or product tampering should be immediately investigated and reported to law enforcement officials and the Food Safety and Inspection Service (FSIS)/State Inspector In-Charge.

6.4.5 Mail Service. The influx of mail into the building provides a conduit for the introduction of hazardous materials. Mail handlers should be trained to recognize and handle suspicious pieces of mail using U.S. Post Office guidelines [32].

6.4.6 Shipping and Receiving Service. All outgoing shipments should be sealed with tamper-proof numbered seals that are included on the shipping documents if warranted by the level of *risk*. Management should require that incoming shipments be sealed with tamper-proof numbered seals and that the seal numbers be shown on the shipping documents for verification prior to entry into the building if warranted by the level of *risk*. Shipping documents with suspicious alterations should be thoroughly investigated. All trailers on the premises should be locked and sealed when not being loaded or unloaded. A policy for off-hour deliveries should be established to ensure prior notice of such deliveries and require the presence of an authorized individual to verify and receive the shipment. Packaging integrity of all incoming shipments should be examined at the receiving dock for evidence of tampering. Advance notification (by phone, e-mail, or fax) should be required from suppliers for all incoming deliveries. Notification should include pertinent details about the shipment, including the name of the driver. Loading docks should be secured to avoid unverified or unauthorized deliveries.

6.4.7 Transportation Service. For facilities/compounds that provide vehicular services for uses such as vanpools, messenger services, corporate officers, etc., the parking areas for these vehicles should be designated. Building owners should consider the *risk* level of their facilities to determine whether operators are required to secure and monitor the vehicles or whether this function may be monitored by camera at the front desk of the building or tenant.

For facilities with **moderate *risk*** or higher, the decision maker should determine whether parking spaces or garages may be constructed directly adjacent to the building. Garage spaces should not be constructed beneath occupied floors of high *risk* facilities.

6.4.8 Medical Service. People require routine and emergency access to medical services. If those services are not available locally for any reason, people in emergency situations are put at *risk*. Those requiring routine services may be hindered by lack of transportation or by congestion when seeking those services if not available locally. Adequate amounts of first-aid supplies should be present in the building to handle injuries. The supplies should be located strategically in the building so that individuals in all sections of the building can readily receive treatment. A core group of the staff should receive adequate training on how to administer first aid.

6.5 Plan for Normal Operations. An operations plan should be developed in simple and readily understandable format and distributed to responsible personnel. This plan should detail the operation of the facility, including the intended performance of all building systems, and shall be kept up to date at all times. These plans are especially beneficial in cases when the building's ownership or building operator changes. These plans should be reviewed periodically with emergency response personnel. These written plans should be properly controlled and kept secured from unauthorized access.

6.5.1 Training

6.5.1.1 Training for Building Occupants. Consider putting together a team of trained building occupants and/or operators who can act in case of emergencies. These teams would not act as a replacement for emergency response personnel but could assist other building occupants in case of an emergency. Duties might include assisting disabled occupants, assisting in evacuation, and communicating with emergency response personnel.

Training for these in-house first responders should consist of first-aid training, CPR, and familiarity with building emergency plans, etc.

6.5.1.2 Training with Emergency Response Personnel. Full-scale response drills should be held periodically and involve each shift to ensure that the building occupants, tenants/employees, in-house first responders, and emergency response personnel understand and practice their duties and responsibilities. These drills should include the operation of the appropriate protective features and the building evacuation, the movement of occupants to designated areas within the building, and the option of remaining in the building as appropriate for the emergency or *threat* being simulated.

6.5.2 Access Control of Visitors and Deliveries. For **moderate *risk*** and lower facilities, consider screening of visitors.

For **serious *risk*** and higher facilities, consider screening of all visitors and employees. If screening of visitors is performed, consider a system to hold items that should not enter a building with a visitor and to return the item when the visitor leaves. Visitors should be verified to have authorized access to tenets.

For **serious *risk*** and higher facilities, consider screening deliveries as well.

6.5.3 Monitoring of System Performance. Building systems should be able to perform as intended. This means that the building operators monitor important parameters that benchmark and track building performance. When building operations adversely affect the performance of the building's systems during an emergency, recommissioning of the building systems should be performed.

Web-based automation control systems are potentially susceptible to cyber attacks. Appropriate safeguards should be taken to prevent unauthorized access. Strong password creation (using a combination of lowercase and uppercase letters, special characters, and numbers) should be fully utilized to limit access to control sequences that are critical to the operation of the building. Consider periodically changing passwords to prevent access to users no longer authorized with access to the system. Additional safeguards include installing server firewalls and intrusion detection systems, maintaining an authorized user list, using virtual private networks between the automation control systems server and users, and employing public-key encryption. Modem connections should either be eliminated or controlled to minimize the possibility of a cyber attack on the system.

6.5.4 Occupant Awareness Programs. The building operators should develop a culture of awareness. Building occupants and operators should report any signs or situations that are outside normal operations or conditions.

6.5.5 Supplies and First Aid. Appropriate and sufficient supplies and first-aid materials for the worst-case scenario should be provided. These supplies and first-aid materials should be indexed and calendared so that replenishment is accomplished before the products expire. These supplies and first-aid materials should be located in a readily identifiable location.

An inventory and stock of emergency equipment should be kept and made available to authorized personnel and in-house first responders. This information can be used to track equipment and supplies that are time sensitive and require replacement or replenishing.

6.5.6 Contact with Emergency Response Personnel and Information Sources. Information on current *threats* changes constantly. Monitor information from federal, state, and local sources that provide *threat* information. This information can assist the decision maker in planning and revising emergency plans.

6.5.7 Normal Maintenance Considerations. Normal maintenance of mechanical and electrical systems enhances security and survivability under extraordinary situations. All components require some routine maintenance because of their mechanical characteristics. These include pumps, boilers, chillers, cooling towers, communication systems, generators, switchgear, and associated motors. Periodic maintenance should be performed to verify the features installed are calibrated and operating as intended.

Table 5 provides guidance to the design professional and building operator on particulate filter maintenance considerations. While exhaustive and definitive values are not possible within this guideline and are dependent upon numerous design choices, Table 5 should provide useful general information. The recommended final pressure drop is based on a fully loaded filter. Filters should be replaced when final pressure drop occurs.

6.6 Plans for Emergency Operations. An emergency plan detailing the coordinated actions of building and maintenance personnel should be developed. This plan shall describe the respective actions to be taken by each person during an emergency. The plan should have detailed procedures for notifying appropriate authorities, building occupants, etc. Because different *threats* require varying responses, detailed scenarios of different *threats* should be created and the corresponding responses explained. If possible, mock trials should test the effectiveness of these plans.

Emergency operations plans should include the following information, which should be kept up to date and available to response personnel:

a. Contact and other appropriate information for emergency response personnel
b. Important hazardous material information for emergency response personnel
c. Locations of emergency service connections, including major electrical and mechanical equipment
d. Location of emergency supplies
e. Location of safe location(s)
f. Shut-off for utility services
g. Building occupancy to assist in search and rescue
h. Detailed explanation of actions to be taken by building operators to specific threats
i. Replacement and replenishment for emergency supplies

Providing specific guidance for particular *threats* is beyond the scope of this guideline. The decision maker should contact professional emergency planners who can assist in creating these plans.

Building occupants should be notified of these plans and should know how these plans apply to them. Building occupants should understand the difference between shelter-in-place and evacuation. Consider handouts for building occupants describing actions to take in different scenarios. FEMA publishes a number of informative guides.

6.7 Personnel Protection. Some facilities need personnel protection masks and/or clothing. For **serious *risk*** and higher,

Table 5 General Filter Selection Considerations

Standard 52.2 MERV	Approx. Standard 52.1 Dust Spot Efficiency	Arrestance	Pressure Drop at Nominal Face Velocity of 500 ft/min, Pa (in. of water)	
			Initial	Final
20	N/A	N/A		
19	N/A	N/A		
18	N/A	N/A		
17	N/A	N/A	199 to 336 (0.80 to 1.35)	500 to 750 (2.0 to 3.0)
16	N/A	N/A	122 to 249 (0.5 to 1.0)	500 to 750 (2.0 to 3.0)
15	>95%	N/A	122 to 249 (0.5 to 1.0)	500 to 750 (2.0 to 3.0)
14	90% to 95%	>98%	92 to 162 (0.37 to 0.65)	250 to 500 (1.0 to 2.0)
13	80% to 90%	>98%	75 to 149 (0.30 to 0.60)	250 to 500 (1.0 to 2.0)
12	70% to 75%	>95%	N/A	N/A
11	60% to 65%	>95%	55 to 112 (0.22 to 0.45)	250 to 500 (1.0 to 2.0)
10	50% to 55%	>95%	N/A	N/A
9	40% to 45%	>90%	N/A	N/A
8	30% to 35%	>90%	65 to 75 (0.26 to 0.30)	250 (1.0)
7	25% to 30%	>90%	60 to 75 (0.24 to 0.30)	250 (1.0)
6	<20%	85% to 90%	57 to 65 (0.23 to 0.26)	250 (1.0)
5	<20%	80% to 85%	N/A	N/A
4	<20%	75% to 80%	N/A	N/A
3	<20%	70% to 75%	N/A	N/A
2	<20%	65% to 70%	N/A	N/A
1	<20%	<65%	N/A	N/A

additional sets of these items should be stored in *areas of refuge*, etc., as described in Section 5.4.4.12. These items should be inventoried and periodically replaced in accordance with manufacturer's recommendations.

There are three physical forms for CBR agents: liquid, vapor, and particulate. Most chemical agents, such as the GB (sarin) and HD (mustard gas), are liquids or vapors; most biological and nuclear radiation agents are particulates (anthrax, atomic fallout). But liquids can be vaporized and most particulates can be mixed into a liquid slurry.

Three routes of CBR entry can lead to a human receiving a dose of a CBR agent. The first route, the oronasal entry, is the most obvious. Second, many agents can attack and enter skin. The third route, cross contamination, involves deposit on the skin (or clothing) surface with subsequent release to the air for entry into the body.

There are also three approaches to protective clothing. They vary in efficacy, ease/possibility of decontamination, and cost, where cost includes not just dollar costs but, more importantly, physiological costs to the wearer. The three approaches are as follows:

a. **Adsorption/Absorption.** This approach, currently adopted for the U.S. military, uses activated charcoal granules in an air-permeable foam garment. This approach has problems; in high winds, heavy sweating, and rain; the agent protection is problematic; and decontamination is impossible.
b. **Barrier Garments.** Totally impermeable to air, vapor, or liquid, this is the approach adopted by the former Warsaw Pact nations. This system is obviously the worst with respect to heat stress but is the easiest to decontaminate and provides the best protection.
c. **Chemical Decomposition.** Used since 1917, this system involves wearing two impregnated layers of garments (an outer uniform and a liner or long underwear). The impregnate was a waxy chlorocarbon. The chlorine would destroy biological as well as chemical agents.

The physiological costs of protection are unavoidable and have been focused on the heat stress associated with any barrier to sweat evaporation. However, the costs also include an increase in heat production; severe degradation in manual dexterity, vision, and communication; difficulties in command control and location of team members; and feelings of isolation.

Table 6 Protective Action Guides for Radiological Dispersion Device Incidents [33]

Phase	Protective Action	Protective Action Guide	Reference
Early	Limit emergency worker exposure	5 rem (or greater under exceptional circumstances) [a]	EPA PAG Manual
	Sheltering of public	1 to 5 rems projected dose [b]	EPA PAG Manual
	Evacuation of public	1 to 5 rems projected dose [c]	EPA PAG Manual
	Administration of prophylactic drugs	For potassium iodine, FDA guidance dose values [d,e]	FDA guidance
Intermediate	Limit worker exposure	5 rem/yr	EPA PAG Manual
	Relocation of general public	2 rems, projected dose first year Subsequent years: 500 mrem/yr projected dose	
	Food interdiction	500 mrem/yr projected dose	FDA guidance [f]
	Drinking water interdiction	500 mrem/yr projected dose	EPA guidance in development
Late	Final cleanup actions	Late-phase PAG based on optimization	

a. In cases when radiation control options are not available or, due to magnitude of the incident, are not sufficient, doses above 5 rems may be unavailable. For further discussion, see Federal Register, Vol. 71, No. 1, Appendix 1.
b. Should normally begin at 1 rem; however, sheltering may begin at lower levels if advantageous.
c. Should normally begin at 1 rem.
d. Provides protection from radioactive iodine only.
e. For other information on medical prophylactics and treatment, please refer to https://emergency.cdc.gov/radiation/index.asp or https://www.orau.org/preparedness/radiation-emergency-medicine.html.
f. DHHS. 1998. Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies. Office of Health and Industry Programs, Center for Devices and Radiological health, U.S Food and Drug Administration, U.S. Department of Health and Human Services, Washington, DC. https://www.fda.gov/regulatory-information/search-fda-guidance-documents/accidental-radioactive-contamination-human-food-and-animal-feeds.

All three approaches of protection have break-through problems, e.g., the time to agent penetration of the material surface. This can require replacement of the uniform or, if possible, decontamination in six hours (goal) or fewer.

Respiratory protective devices are available to reduce doses of inhaled particles and gases. A range of devices is available with varying levels of protection, from masks that reduce particle concentrations in inhaled air to full protection with full hooding and provision of a safe air supply.

If any stockpiling of protective clothing/equipment is undertaken, it should be limited. Power air-supplied (battery-powered) respiratory hoods (not masks) should be considered. For protective clothing, simple plastic hooded ponchos should be considered. These caveats are based on the very real problems of donning and sealing, extensive requirements for fitting and testing of fit, the resultant physiological and psychological strains of wear, and the lack of facilities for decontamination prior to removal in order to avoid cross contamination.

Filtration, described in Section 5.4.3.1.2, addresses particulate as well as gas adsorption. Radioactive particles may be trapped with such enhanced particulate filtration, thereby reducing continuous movement of those particles through the airstream as they continue to emit alpha, beta, and gamma radiation. Protective clothing addresses alpha radiation, but personnel still need to be concerned with the other radiation not trapped in enhanced filtration. Film badges have been developed for use by personnel for rapid indication for elevated radiation exposures. Recent protective action guides have been published for radiological dispersal devices and improvised nuclear devices. DHS directives combine EPA and FDA guidelines that seek to limit general public exposure to radio nuclides with regard to air, food, and drinking water. Table 6 provides a summary of current references proposed by DHS. This information provides additional guidance for personnel protection.

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(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

INFORMATIVE APPENDIX A RISK MANAGEMENT EXAMPLE

A1. INTRODUCTION

A four-step *risk* management process is introduced in Section 4 of this guideline. For additional help, this appendix also presents an example case through which the process can be further explained.

A2. ASSESSING THE RISK

This preliminary screening tool determines whether further *risk* management is needed. Consultants and engineers face a new level of assisting building owners, building occupants, and building operators to assess exposure caused by an *extraordinary incident*. The exposure level matrix, shown in Figure A-1, provides the owner, operator, occupant, engineer, etc., with a means to evaluate the exposure of one or more facilities quickly and objectively.

A2.1 Identify the Decision Maker. The decision maker is responsible for the *risk* exposure of the facility, employees, software, and equipment. This requires setting the limits of possible harm, determining the parameters for how *risk* is measured, and dedicating resources for the project.

A2.2 Conduct a Threat Assessment. Review the site and list the possible *threats* to which the site may be exposed. Possible *threats* may include, but are not limited to the following:

a. Wind (high winds, hurricanes, or tornadoes)
b. Floods (surface water, tsunami, storm surge, level breeches, pipe failure, and other sources of water intrusion)
c. Quakes
d. Fire (accidental and intentional)
e. Vandalism
f. Kidnapping
g. Blast (small to large—letter bomb, suicide bomb, and vehicular bomb)
h. Sabotage
i. Cyber attacks (intrusion into the computer network or system)
j. Utility outage (electrical, natural gas, water, and communication)
k. Chemical, biological, or radiological (both internal and external)

A2.3 Conduct a Vulnerability Assessment. Identify the building's *vulnerability* to the *threats*. For example, the *threat* could be "chemical attack." *Vulnerabilities* are specific to the facility: method of mail delivery, broken window, piping system, outdoor air intake, etc. List the *vulnerabilities* to develop options (solutions) to mitigate the *risk*. Further information can be found in recent publications on formal procedures for *vulnerability* assessments, such as *Physical Security Assessment for Department of Veterans Affairs Facilities: Recommendations of the National Institute of Building Sciences Task Group to the Department of Veterans Affairs*, (see "Security Design" in Informative Appendix B).

Review the site and list the *vulnerabilities* of the site. Possible *vulnerabilities* may include the following:

a. Outdoor air intake location
b. Physical access to the property or building
c. Physical access to critical rooms or functions
d. Filters
e. Ventilation
f. Fire protection
g. Electronic access to the computer system or network
h. Medical procedures and processes
i. Flood protection
j. Wind loading
k. Structural limits and design
l. Utility backups
m. Communication backups
n. Employee protection and welfare
o. Evacuation plan
p. Parking locations
q. Sewer and culverts

A2.4 Assign a Risk Category. The *risk* categories, levels, and weighing factors are determined in consultation with building owners, occupants, operators, and *risk* consultants. Each owner, occupant, and operator has unique criteria for evaluating *risk* and assigning values. The goal of this section is to objectively state, document, and rank these values to determine the facility's preliminary exposure level. Most facilities will receive ratings of 1 or 2 out of 5 using the exposure level matrix in Figure A-1.

The *risk* categories are listed across the top of Figure A-1. These are items that the owner, occupant, and operator think are important to the continued operation of the organization. These categories, among others, should be considered by building owners, occupants, and operators. It is the responsibility of this guideline's user to confirm or replace categories with those deemed important to the owner, occupant, and operators. The user can expand or collapse the list of categories to fit his or her unique criteria.

In Figure A-1, the sample matrix is based on the following *risk* categories:

a. **People count.** Includes all individuals in the building at any given time.
b. **Received *threats*.** Tangible and intangible *threats* made by individuals or organizations toward a building or organization.
c. **Critical nature or building function.** The subjective value of the business to society, customers, other businesses, or internal customers.
d. **Time required to recover the operation.** The time span to return to 80% of normal business operations. The longer the time, the greater the exposure.
e. **Dollar value.** The value of the product, equipment, and services within the facility, of the facility itself, of the information resources, and of the personnel.
f. **Public access.** The ease with which the public can enter a building or facility.

Category Level	People Count	Received Threats	Critical Nature or Building Function	Time Required to Recover the Operation	Dollar Value	Public Access
1						
2						
3						
4						
5						
Score						
Weighting Factor						
Sum of the weighing factors must equal 100%.						
Calculated Score						
Exposure Level		*Sum of the Calculated Scores*				

Figure A-1 The exposure level matrix.

Category Level	People Count	Received Threats	Critical Nature or Building Function	Time Required to Recover the Operation	Dollar Value	Public Access
1	0 to 10	0 to 1	Low	Less than 2 days	Less than $2,000,000	Low
2	11 to 60	2 to 4	Medium low	2 to 14 days	$2,000,000 to $10,000,000	Medium low
3	61 to 120	5 to 8	Medium	14 days to 3 months	$10,000,000 to $50,000,000	Medium
4	120 to 1,500	9 to 12	Medium high	3 to 6 months	$50,000,000 to $100,000,000	Medium high
5	More than 1,500	More than 12	High	More than 6 months	More than $100,000,000	High
Score						
Weighting Factor	20%	10%	30%	10%	10%	20%
Sum of the weighing factors must equal 100%.						
Calculated Score						
Exposure Level		*Sum of the Calculated Scores*				

Figure A-2 Sample exposure level matrix.

Other categories that could be used in the table include national monument/symbol or distance from a national monument/symbol.

Levels in the left-hand column indicate the level of exposure. Level 1 has the lowest exposure level, while Level 5 has the highest exposure level. The users assign each level a value or range of values. For example, in the people-count column, one could assign values as follows:

- Level 1: 10 or less
- Level 2: 11 to 60
- Level 3: 61 to 120
- Level 4: 121 to 1500
- Level 5: more than 1500

The process continues until all the levels are completed for each category.

Next, a weighing factor (expressed as a percentage) is assigned to each of the categories. Again, it is the responsibility of the user to develop weighing factors based on what is important to the owner, occupant, and operators. An example of this matrix is shown in Figure A-2.

Category Level	People Count	Received Threats	Critical Nature or Building Function	Time Required to Recover the Operation	Dollar Value	Public Access
1	0 to 10	0 to 1	Low	Less than 2 days	Less than $2,000,000	Low
2	11 to 60	2 to 4	Medium low	2 to 14 days	$2,000,000 to $10,000,000	Medium low
3	61 to 120	5 to 8	Medium	14 days to 3 months	$10,000,000 to $50,000,000	Medium
4	120 to 1,500	9 to 12	Medium high	3 to 6 months	$50,000,000 to $100,000,000	Medium high
5	More than 1,500	More than 12	High	More than 6 months	More than $100,000,000	High
Score	2	2	1	2	2	2
Weighting Factor	20%	10%	30%	10%	10%	20%
Sum of the weighing factors must equal 100%.						
Calculated Score	0.4	0.2	0.3	0.2	0.2	0.2
Exposure Level	1.5	*Sum of the Calculated Scores*				

Figure A-3 Sample exposure level matrix for small office building.

Our example is an office building near a small town in rural America. Fifty employees are housed in the building with five visitors in the office. The value of the building and contents are estimated at $3,000,000. The critical nature of the building function is “low” and two bomb *threats* have been received in the last year. Management assigns a “low” critical nature to the building because temporary facilities can be found using garages or hotels. The building is secured using card readers to unlock the doors. The expected recovery time to resume business is three days. The users determine the following values and set up the matrix as described in Figure A-2.

Using the description and the levels, determine the score for each category. For instance, the building houses 50 employees and 5 visitors for a total count of 55. Level 2 has a people count from 11 to 60, so the building gets a score of 2 in the people-count column. Two *threats* received give a score of 2. The critical nature of the building is “low,” yielding a score of 1. The operations can be resumed in 3 days, giving a score of 2. The value of $3,000,000 is in Level 2, between values $2,000,000 to $10,000,000, giving a score of 2. The security systems limit public access 24 hours a day, so public access is low, giving a score of 2.

To obtain the calculated score, multiply the score by the weighing factor in each column. Then, sum the individual calculated scores to determine the exposure level. The completed matrix should look like the one in Figure A-3.

On a scale of 1 to 5, the building has a 1.5 exposure level. To verify whether this value is realistic, try rating the World Trade Center, Pentagon, or White House command bunker. If the White House command bunker receives a score lower than 5, then you should adjust the weighting factors used for your facility. As Willhite and Norton (2002a) observe in their research on *risk* management, “It is important to remember that these tools cannot replace human judgment. The tools aid in the analysis of data” (see “*Risk* Management” in Informative Appendix B). It should also be noted that *extraordinary incidents* are rare occurrences. There are difficulties in establishing a credible probability of occurrence due to the limited amount of data collected.

For multiple occupancies, you should complete an exposure level matrix for each occupancy. You then have two options: you can take the worst case and use that score, or you can develop a matrix with weighting factors for each occupancy and calculate a composite score.

End-user management determines where the exposure level above which the need for further assessment occurs. For instance, Exposure Levels 1 and 2 may need no further assessment. Exposure Level 3 is the middle ground and may be decided on a case-by-case basis. Exposure Levels 4 and 5 always require further study.

A2.5 Establish Criteria. Criteria must be established to measure the success or failure of an intervention scheme. The decision maker decides those criteria that are applicable to the facility. If, for example, the decision maker determines that the facility must be able to remain open for five days in the event of a power outage to maintain business, and also determines that power, heating, and air conditioning are to be provided to certain areas of the facility, the designers can design the systems to meet these criteria.

A2.6 Calculate the Load Imposed by the Threat. For the *threat* being considered here, the design professional determines the load using standard load classification procedures. From this load, the designer determines the size and the capacity needed to carry the facility or facilities through the incident and meet the criteria. Based on the criteria in Section A2.5, the designer determines the maximum capacity on the HVAC system and its load profile and passes the information to the electrical designer, who uses the information to determine the size of the generator and the volume of fuel needed to last five days.

A2.7 Develop and Evaluate Intervention Schemes. The designer develops and evaluates alternative intervention schemes that can meet the criteria. Using the example from Section A2.6, the designer considers using an ice or water thermal storage system instead of using chillers to provide cooling. Depending on the selected storage system capacity, it may allow for a smaller generator, fuel storage tank, chillers to be purchased, better control and use of the chillers, and for the storage system to be used for demand-side control. A disadvantage is the additional cost of the thermal storage system.

A2.8 Determine if the Criteria Are Met. The designer verifies that each of the systems meets the criteria. If an intervention scheme does not meet the criteria, it is dropped from consideration.

A2.9 Select an Intervention Scheme to Use. The decision maker reviews the various intervention schemes and selects those that provide an optimum solution to the facility with consideration to the following:

a. Health
b. Safety
c. Welfare
d. Exposures
e. System performance
f. Economics

A2.10 Run the Assessment Using Multiple Threats. The final task is to assess how the facility performs during multiple *threats*. This task is informal and used to gain an idea how the system is stressed when multiple *threats* are considered. To make this assessment, list some *threats* that could occur at the same time and ask how the facility will perform during a flood, power outage, and wind storm. If a weakness is discovered, then further alternatives can be explored to resolve the issue.

A3. IDENTIFYING THE RISK

A systematic method helps the organization discover the significant *risks*. One method is to use group brainstorming. A sample group could consist of the owner, the tenant, an occupant, and an operator. Each member contributes one *risk* per pass around the group. It is acceptable to pass at any point. A facilitator records each individual's contribution of *risk*. The exercise stops when everyone passes. Judgment and criticism are withheld until everyone has passed. Questions are limited to gaining an understanding of each *risk*. The group should attempt to identify unknown as well as known *risks*.

A4. ESTIMATING THE PROBABILITY OF RISK OCCURRENCE

The probability of occurrence is the most difficult variable to assess because *extraordinary incidents* are rare. The group could develop a table showing probability of successful occurrence, like the one shown in Table A-1. The probabilities are based on the occurrence of *extraordinary incidents*.

Table A-1 Sample Probability of Successful Occurrence
Source: Willhite and Norton (2002b)

Descriptor	Occurrence (Once in XX Years)	Probability
• Least likely to occur	• Greater than 1000	• Less than 0.001
• Unlikely to occur	• 500 to 1000	• 0.002 to 0.001
• Average probability of occurrence	• 250 to 500	• 0.004 to 0.002
• Likely to occur	• 50 to 250	• 0.02 to 0.004
• Most likely to occur	• Less than 50	• Greater than 0.02

The low degree of occurrence shows the difficulty in establishing the true *risk* of an occurrence of an *extraordinary incident*.

A5. ASSESSING THE VALUE OF LOSS FOR RISK ASSESSMENT

First, determine the losses associated with the identified *risks* and their costs. Examples of losses to the organization are employee downtime, loss of customers, potential loss of life, current and future losses, and lost productivity due to nonquantifiable factors such as fear, reduced capacity, quality of life (such as extra waiting time at airports), etc. When reviewing losses, Willhite and Norton (2002) recommend asking the following questions: (a) When are the losses likely to occur? (b) How badly will our ability to achieve the organization's objectives be affected? and (c) How likely is the incident to occur?

Second, quantify the losses to the organization in dollars. It is desirable to have a basis for comparisons for alternate courses of action. An example is shown in Table A-1.

Total loss for the example is estimated at $5,715,600 based on the following factors: lost productivity, equipment rental, space rental, insurance deductible, loss of new business, loss of quality of life, reduced business capacity, legal services, and recovery services.

A6. RANKING THE RISKS

Impacts to the organization can be classified as *critical*, *serious*, *moderate*, *minor*, and *negligible*. Table A-2 provides the definitions for making these classifications.

A *risk* rating can now be developed using probability (from Table A-1) and impact definitions (from Table A-2). Assign each *risk* a probability and impact. The resultant chart, Table A-3, can be used to rate each *risk* as *high*, *medium*, or *low*.

Using the example of a chemical attack on the small office in rural America, management determines that the attack falls in the least-likely-to-occur row and the moderate-impact column. The *risk* rating chart gives a medium rating.

Now rank the *risk* most-to-least critical, using the *risk* rating and human judgment. The Borda (1781) method ranks *risk* from most-to-least critical on the basis of multiple evaluation criteria. It is based on a positional method, in that it assigns a score corresponding to the positions in which an

Table A-2 Risk Categories
Source: Willhite and Norton (2002b)

Critical	An incident that, if it occurred, would cause failure of the performance of the facility or major impact on occupant health and safety.
Serious	An incident that, if it occurred, would cause a major disruption in the performance of facility or would have a significant impact on occupant health and safety.
Moderate	An incident that, if it occurred, would cause significant disruption in the performance of facility or some impact on occupant health and safety.
Minor	An incident that, if it occurred, would cause only a small disruption in the performance of facility; some temporary occupant discomfort might occur but no impact on occupant health and safety.
Negligible	An incident that, if it occurred, would have little or no effect on the performance of the facility and no impact on occupant health and safety.

alternative appears within each voter's ranked list of preferences, and the alternatives are sorted by their total score. This determines the priority for evaluating *risk*. (See Borda [1781] and Garvey and Lansdowne [2002] in "Risk Management" in Informative Appendix B.)

A7. IDENTIFYING THE BUILDING'S VULNERABILITIES

Identify the building's *vulnerability* to the *risks*. For this example, the *risk* is a chemical attack. *Vulnerabilities* are specific to the building and could be delivery by mail, broken window, piping system, accidental spillage, outdoor air intake, etc. List the *vulnerabilities* to develop options (solutions) to mitigate the *risk*. Additional information on *vulnerabilities* is found in Sections 3 through 5. Further information can be found in recent publications on formal procedures for *vulnerability* assessments, such as *Physical Security Assessment for Department of Veterans Affairs Facilities: Recommendations of the National Institute of Building Sciences Task Group to the Department of Veterans Affairs* (see Informative Appendix B).

A8. DETERMINING THE LIFE-CYCLE COST ANALYSIS

Life-cycle cost is one method to evaluate and rank options. The base case is the current situation before mitigation. The loss is distributed over time by multiplying the loss by the probability (ρ) of occurrence (see Sims [2002] in "Security Design" in Informative Appendix B). The unmitigated loss is the cost of the loss times the probability of occurrence before mitigation (ρ1). The mitigated loss is the loss times the probability of occurrence after mitigation (ρ2).

$$\text{Unmitigated loss} = \text{Cost of the loss } x\ (\rho 1)$$

$$\text{Mitigated loss} = \text{Cost of the loss } x\ (\rho 2)$$

In life-cycle cost, each organization selects its break point based on their experiences and financial policy. The following example uses our small office building in rural America.

The catastrophic loss from a chemical attack is $5,715,600 from above.

The company estimates the probability of occurrence before mitigation as (ρ1) 1 in 100 chance of the attack being successful.

The unmitigated *risk* is $5,715,600 × 0.01 (ρ1), or $57,156.

The company determines that installing an outdoor air pretreatment system to reduce the attack to cost $35,000 and, as a result, reduces the probability of occurrence after mitigation to (ρ2) 1 in 1000 for a successful attack. The annual increase in operating expense is estimated at $2900 for material, maintenance, and energy.

The mitigated *risk* is $5,715,600 × 0.001 (ρ2), or $5716.

Assumptions for the life-cycle cost example are as follows:

a. Forty-year life, as most building life exceeds 40 years.
b. Fifteen-year life for the new equipment.
c. Project is 100% capitalized.
d. Tax rate is 35%.
e. Depreciation is over 39 years.
f. Discount rate is 7%.
g. Inflation rate is 3%.
h. Initial cost of the pretreatment equipment is $35,000 and is spent every 15 years.
i. Annual energy, maintenance, and material expense increases $2900 after installation of the pretreatment device.
j. Annual salary expense is $3,250,000 and can be reduced to $3,185,000 in year five after installation of the pretreatment device.
k. Distributed loss before mitigation: $57,156.
l. Distributed loss after mitigation: $5716.
m. All values stated are in present value; inflation and discount calculations were performed.

The 40-year life-cycle cost before mitigation is $43,300,000. The 40-year life-cycle cost after mitigation is $42,000,000. The recommendation is to proceed with the mitigation. Other options can be studied similarly and then ranked by their evaluation methodology. Table A-4 shows a brief sample *risk* mitigation plan.

Note that some treatments have the ability to address several *risks* or *vulnerabilities*. Also note that the tables are readily adaptable for spreadsheet use.

Table A-3 Sample Risk Rating Chart: A Comparison of Probability and Impact

	Negligible	Minor	Moderate	Serious	Critical
Least Unlikely to Occur	Low	Low	Medium	Medium	High
Unlikely to Occur	Low	Low	Medium	Medium	High
Average Probability of Occurrence	Low	Medium	Medium	Medium	High
Likely to Occur	Medium	Medium	Medium	Medium	High
Most Likely to Occur	Medium	Medium	High	High	High

Table A-4 Sample Risk Mitigation Plan

Priority	Incident	Action or Response Plan
1	Bomb or intentional fire	Company bomb and fire procedures, remote alarm, install fire sprinkling system.
2	Contamination/poisoning (interior source)	Develop written procedures, shut down fans, isolate the source, contact authorities, and start decontamination procedures.
3	Contamination/poisoning (exterior source)	Develop written policy, fence off or move air intakes to the roof, filtration, contact authorities, and start decontamination procedure of affected area.

(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

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(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

INFORMATIVE APPENDIX C
REFERENCE INFORMATION

C1. DEVELOP AND EVALUATE INTERVENTION

Several economic evaluation methods have been standardized and published by ASTM. See *ASTM Standard on Building Economics* [C-1] for guidance on the use of economic evaluations. See Section 4.2.7.

C2. PROGRESSIVE COLLAPSE

For **serious *risk*** and higher, ASCE/SEI Standard 7, *Minimum Design Loads for Buildings and Other Structures* [C-2], describes progressive collapse and offers additional guidelines. See Section 5.4.2.2.

C3. FIRE ALARM AND DETECTION SYSTEMS

For **serious *risk*** or higher, consider incorporating NFPA 72, *National Fire Alarm Code* [C-3], requirements for survivability regardless of building height. See Section 5.4.3.4.5.

C4. BUILDING OCCUPANCY TYPES—OFFICES

Refer to NFPA 75, *Standard for the Protection of Information Technology Equipment* [C-4], for information on protecting information technology equipment. See Section 5.5.1.

C5. REFERENCES

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POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

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