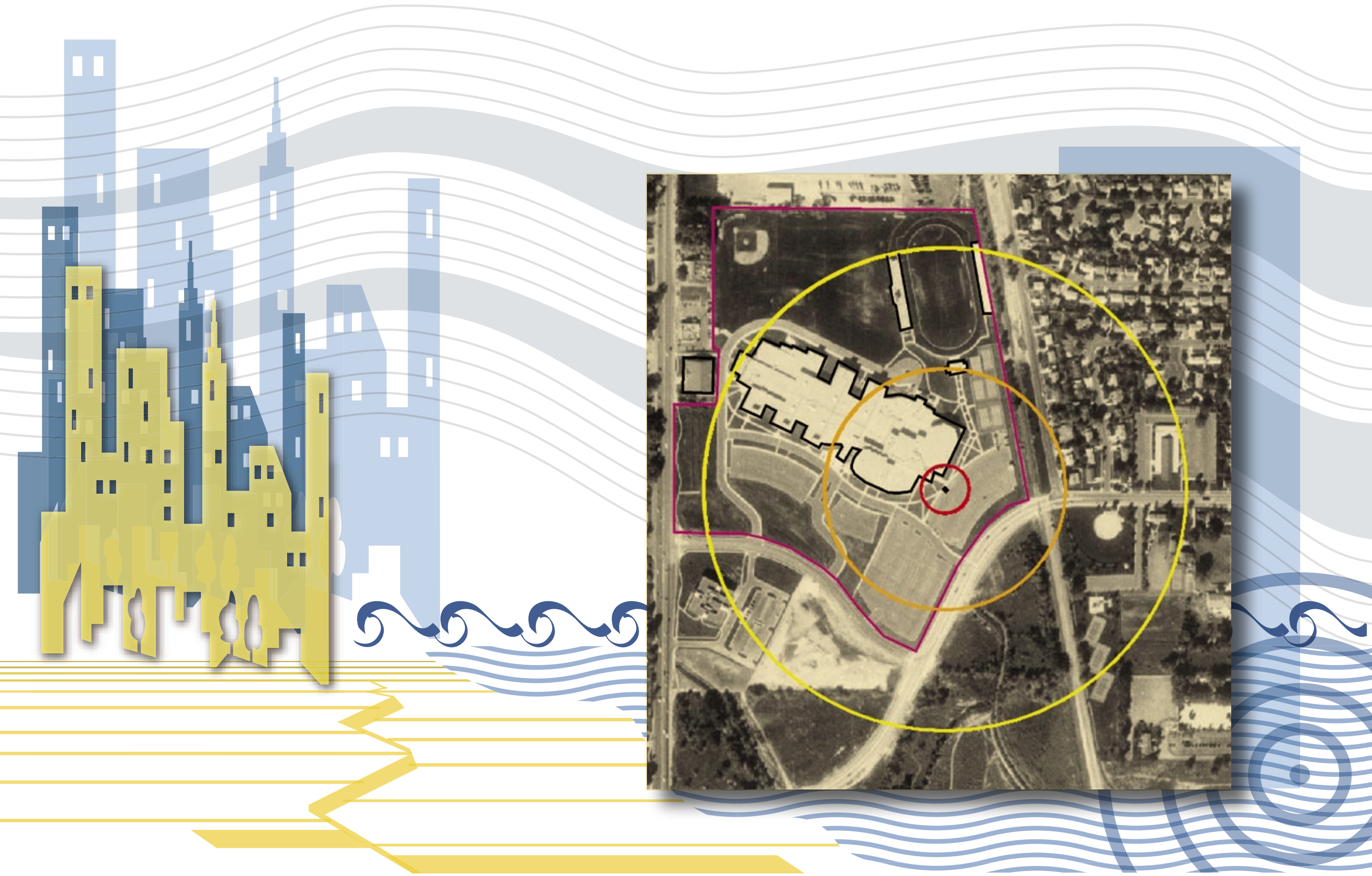

Risk Management Series

Primer

to Design Safe School Projects in Case of Terrorist Attacks

December 2003

FEMA

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RISK MANAGEMENT SERIES

Primer *to* Design Safe School Projects in Case of Terrorist Attacks

PROVIDING PROTECTION TO PEOPLE AND BUILDINGS

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The creation of the Department of Homeland Security (DHS) is one of the most significant transformations in the Federal Government in decades, establishing a department whose first priority is to protect the nation against terrorist attack. Within the DHS, the Directorate of Emergency Preparedness and Response (EP&R) is focused on ensuring that our nation is prepared for catastrophes, including both natural disasters and terrorist assaults.

This Primer for Protection of Schools Against Terrorist Attacks provides guidance to protect students, faculty, staff, and their school buildings from terrorist attacks. It also provides guidance to the building science community of architects and engineers working for local institutions on school projects.

This document is intended for use by schools who feel that they are at risk to terrorist attacks. It provides necessary guidance to those who desire to increase the performance of their school and related infrastructure. Not all schools are at risk of terrorist attacks. The decision-makers in each school district should use current and available threat information from the proper sources to make this determination. The use of experts to apply the methodologies contained in this document is encouraged.

This primer references several sources for additional information, including publications completed by other government agencies. The reader is encouraged to obtain additional guidance.

This document was prepared by the Building Sciences and Technology Branch of the Mitigation Division, part of EP&R. DHS would like to thank the following agencies for their contribution and input to this publication:

- General Services Administration
- Naval Facilities Engineering Service Center
- Naval Facilities Command (NAVFAC) Criteria Office

- USACE Protective Design Center
- Department of Veterans Affairs
- Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health
- Department of Justice, Office of Domestic Preparedness (DHS - Border and Transportation Security)
- United States Air Force - Civil Engineer Support Agency

FOREWORD AND ACKNOWLEDGMENTS

BACKGROUND

The purpose of this primer is to provide the design community and school administrators with the basic principles and techniques to make a school that is safe from terrorist attacks and at the same time is functional, aesthetically pleasing, and meets the needs of the students, staff, administration, and general public. Protecting a school building and grounds from physical attack is a significant challenge because the ability to design, construct, renovate, operate, and maintain the facility is spread across numerous building users, infrastructure systems, and many building design codes.

An American high school

There is a strong interest in the United States (U.S.) in ensuring the safety of students, faculty, and staff in our schools. Schools are integral parts of their communities. On any given weekday, nearly 53 million young people aged 5 to 17 attend more than 117,000 public and private schools where 6 million adults work as teachers or staff (counting students, faculty, and staff, this constitutes more than one-fifth of the U.S. population). Additionally, schools are resources for their communities. Many schools are used as shelters, command centers, or meeting places in times of crisis. Schools are also used widely for polling and voting functions. In some communities, schools are places of health care delivery.

Schools may or may not be the targets of terrorism, but they are certain to be affected by terrorism, whether directly or indirectly.

On September 11, 2001, four elementary schools and three high schools located within 6 blocks of the World Trade Center were just beginning classes when the first plane hit the north tower. Thousands of children were exposed to the dust clouds from the collapsing buildings. Even those children not in the immediate vicinity experienced a great deal of anxiety. Children in at least three states (New York, New Jersey, and Connecticut) had parents working in or around the World Trade Center that day. In the Washington, DC, area, schools faced similar situations after the Pentagon was attacked.[1]

Many Americans feel that schools should be the safest place our children can be, perhaps at times even safer than the homes in which they live. Security is not a standalone capability; it is a critical design consideration that should be constantly reviewed and scrutinized from the design phase through construction or rehabilitation and onto building use.

The focus of this primer will be on the threats posed by potential physical attacks on a school by terrorists. Attacking schools and school children could be a highly emotional and high profile event. At the time of publication of this primer, there have been no direct terrorist threats against a school known to the public; however, schools could be indirectly threatened by collateral damage from a terrorist attack directed at nearby facilities. Protecting a school against terrorist attack is a challenging task. A school may have considerable vulnerabilities, because of its well defined periods of use, designated access points, storage of sensitive personal information, minimal security forces, and numerous avenues of penetration and escape for attackers.

This primer should be used in conjunction with the Federal Emergency Management Agency (FEMA) 426, *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings,* and FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks.*

[1] National Advisory Committee on Children and Terrorism (NACCT)

SCOPE

This primer presents an approach to protecting schools at risk from terrorist attacks. The information presented is intended primarily for architects and engineers, or school administrators with a technical background. This publication is designed to meet the needs of all schools, including those with serious security concerns. Because security concerns of individual schools vary greatly, some users with modest security concerns may feel beleaguered by the amount of information and technical approach presented. They should feel free to select the methods and measures that best meet their individual situations while gaining a general appreciation of security concerns and risk management.

Several design philosophies and techniques have been incorporated into this primer, including the Department of Defense (DoD) Minimum Antiterrorism Standards, the Army and Air Force Security Engineering Manual, the General Services Administration (GSA) Public Building Standards, the Department of Veterans Affairs (VA) Building Vulnerability Assessment Checklist, and the Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH) Guidelines for Airborne Contaminants.

ORGANIZATION AND CONTENT OF THE PRIMER

This publication contains many how-to aspects based upon current information contained in FEMA, Department of Commerce (DOC), DoD (including Army, Navy, and Air Force), Department of Justice (DOJ), GSA, VA, CDC/NIOSH, and other publications. It is intended to provide an understanding of the current methodologies for assessing threat/hazard, vulnerability, and risk, and the design considerations needed to improve protection of new and existing buildings and the people occupying them. As needed, this primer should be supplemented with more extensive technical resources, as well as the use of experts when necessary.

- Chapter 1 presents a methodology for architects, engineers, and school administrators to analyze the safety of students, teachers, and staff for vulnerabilities to various terrorist threats. The methodology presented will assist schools in performing risk management by helping them to identify the best and most cost-effective terrorism mitigation measures for their unique security needs.

- Chapters 2 and 3 discuss site and layout, and building design guidance and safety plans, respectively, and mitigation measures or comprehensive architectural and engineering design considerations to provide an acceptable level of protection. Specifically, Chapter 2 discusses comprehensive architectural and engineering design considerations for the school site, from the property line to the school building. Chapter 3 presents design considerations for the building envelope.

- Chapter 4 is a brief discussion of explosive blast theory. Chapter 5 presents chemical, biological, and radiological (CBR) measures that can be taken to mitigate school vulnerabilities and reduce associated risk for these terrorist tactics or technological hazards.

- Chapter 6 is a standalone description of the concept of safe rooms within schools that will resist CBR and blast threats intended to provide school board members and decision-makers with the basic components of a protective system.

- Appendices A, B, and C contain acronyms, general definitions, and chemical and biological agent characteristics, respectively. Appendix B is an extensive glossary with terminology used in the report.

- Appendices D and E present a comprehensive bibliography of publications (including information for obtaining the publications), and the associations and organizations capturing the building security guidance needed by the building sciences community (including web sites), respectively.

- Appendix F contains the Building Vulnerability Assessment Checklist.

ACKNOWLEDGEMENTS

Principal Authors:

Michael Chipley, UTD, Inc.

Wesley Lyon, UTD, Inc.

Robert Smilowitz, Weidlinger Associates, Inc.

Pax Williams, Battelle Memorial Institute

Contributors:

Milagros Kennett, FEMA, Project Officer, Risk Management Series Publications

Eric Letvin, Greenhorne & O'Mara, Inc., Consultant Project Manager

Michael Kaminskas, UTD, Inc.

Christopher Arnold, Building Systems Development, Inc.

Shawn Fenn, FEMA

Randall Hoffman, UTD, Inc.

Damian Kolbay, UTD, Inc.

Eve Hinman, ATC/Hinman Consulting Engineers, Inc.

Robert Burns, UTD, Inc.

Curt Betts, U.S. Army Engineer District, Omaha

Connie Deshpande, Department of Education

Bill Modzeleski, Department of Education

Randy Haslam, Jordan, Utah, School District

Deb Daly, Greenhorne & O'Mara, Inc.

Wanda Rizer, Greenhorne & O'Mara, Inc.

Julie Liptak, Greenhorne & O'Mara, Inc.

Bob Pendley, Greenhorne & O'Mara, Inc.

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ASSET VALUE, THREAT/HAZARD, VULNERABILITY, AND RISK 1

This chapter presents methodologies for architects, engineers, school administrators, and state and local officials working in the building sciences field to identify the most effective mitigation measures to achieve a desired level of protection against terrorist attacks. These methodologies will help designers define asset value and evaluate vulnerability assessment information for the purpose of integrating threat/hazard into a design basis. Architects and engineers will be able to identify the best and most cost-effective terrorism mitigation measures for each building's unique security needs. Mitigation measures are conceived by the design professional and are best incorporated into the building architecture, building systems, and operational parameters, with consideration for life-cycle costs. The methodologies described in this chapter can be used for new buildings during the design process, as well as for existing buildings undergoing renovation. A key tool in the assessment process is provided for the designer in the last section of this chapter, the Building Vulnerability Assessment Checklist.

In order to create a safe school environment, many factors must be considered. Figure 1-1 depicts the assessment process presented in this primer to help each school identify the best and most cost-effective terrorism mitigation measures for its own unique security needs. Section 1.1 identifies the value of a school's assets (e.g., people, buildings, equipment, and processes) that need to be protected, recognizing that students, faculty, and staff will always be a school's most vital asset requiring protection. Section 1.2 describes how to conduct a threat/hazard assessment to identify and define the threats and hazards that could cause harm to a school. Section 1.3 discusses how to perform a vulnerability assessment to identify school weaknesses that might be exploited by a terrorist or aggressor. Combining the results of the asset value, threat, and vulnerability assessments in Sections 1.1 through 1.3, the next step in the assessment process is to perform a risk assessment (Section 1.4) to determine to what degree a school's assets are vulnerable

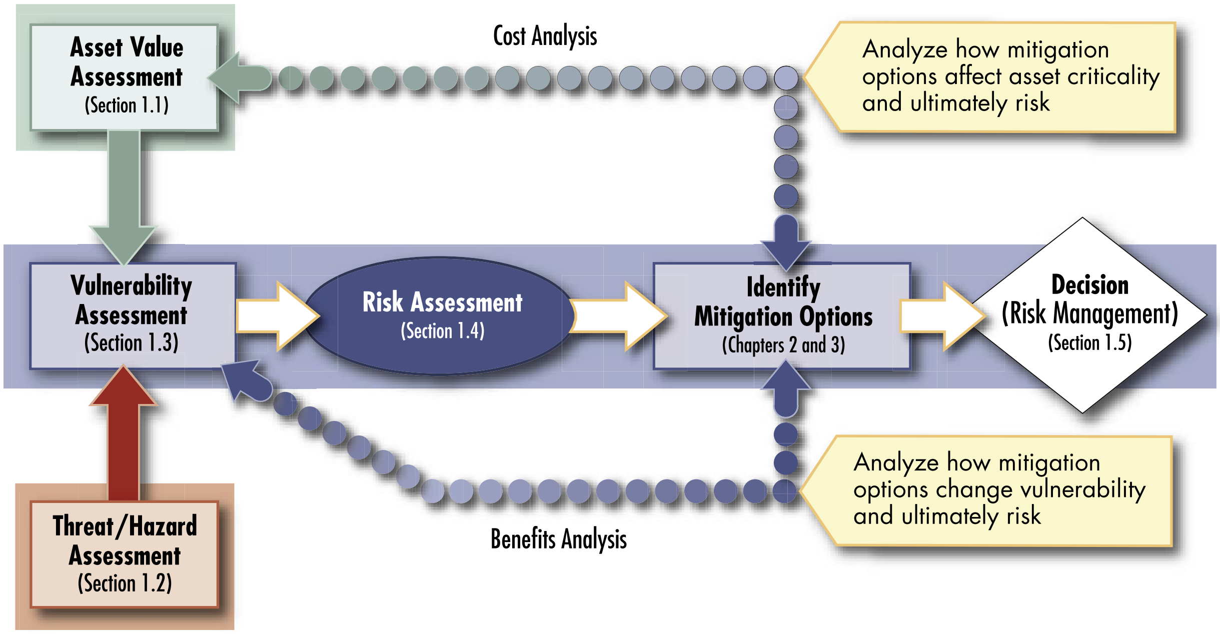


Figure 1-1 The assessment process model

to attack. The final step of the process is presented in Section 1.5, where risk management decisions are discussed to prioritize and decide on the best and most cost-effective terrorism mitigation measures to implement to achieve the desired level of protection.

A school assessment is best performed by engineering and security professionals who are experts in risk management, building design, blast effects, and chemical, biological, and radiological (CBR) attacks, as well as the latest antiterrorism (AT) security measures. If it is not feasible to hire professionals, members of the design community and/or school administrators can perform an assessment using the methodology presented in this primer. Some schools may choose to take a hybrid approach, hiring specialists or consultants to help perform individual portions of the assessment process.

1.1 ASSET VALUE ASSESSMENT

This section will describe how to perform an asset value assessment (the first step of the assessment process), to identify people and the asset value. To facilitate identifying people and the value of a school's assets, it is useful to conduct interviews of the people who are most familiar with them. Inputs from school administrators, teachers, nurses, custodial staff, cafeteria staff, and students, as well as any others who can help identify the most valuable assets should be sought. In order to conduct productive interviews, a list of areas to be covered should be generated and prioritized prior to the actual interviews. Thorough planning and research to generate relevant questions will aid the process and yield better results.

An asset is a resource of value requiring protection.[1] An asset can be tangible (e.g., students, faculty, staff, school buildings, facilities, equipment, activities, operations, and information) or intangible (e.g., processes or a school's reputation). In order to achieve the greatest risk reduction at the least cost, identifying and prioritizing a school's critical assets is a vital first step in the process to identify the best mitigation measures to improve its level of protection prior to a terrorist attack. Recognizing that people are a school's most critical asset, the process described below will help identify and prioritize school infrastructure where people are most at risk and require protection.

Identifying a school's critical assets is accomplished in a two-step process:

Step 1: Define and understand the school's core functions and processes

Step 2: Identify school infrastructure

- Critical components/assets
- Critical information systems and data
- Life safety systems and safe haven areas
- Security systems

[1] Appendix B is a glossary of assessment and security terminology. Appendix C contains chemical and biological agent characteristics.

1.1.1 Identifying School Core Functions

The initial step of an asset value assessment is the determination of core functions and processes necessary for the school to continue to operate or provide services after an attack. The reason for identifying core functions/processes is to focus the design team and school administrators on what a school does, how it does it, and how various threats can affect the school. This provides more discussion and results in a better understanding of asset value. Factors that should be considered include:

- What are the school's primary services or outputs?
- What critical activities take place at the school?
- Who are the school's occupants or visitors?
- What inputs from external organizations are required for a school's success?

1.1.2 Identifying School Infrastructure

After the core functions and processes are identified, an evaluation of school infrastructure is the next step. To help identify and value rank infrastructure, the following should be considered, keeping in mind that the most vital asset for every school is its people:

- Identify how many people may be injured or killed during a terrorist attack that directly affects the infrastructure.
- Identify what happens to school functions, services, or student satisfaction if a specific asset is lost or degraded. (Can primary services continue?)
- Determine the impact on other organizational assets if the component is lost or can not function.
- Determine if critical or sensitive information is stored or handled at the school.
- Determine if backups exist for the school's assets.
- Determine the availability of replacements.

- ❍ Determine the potential for injuries or deaths from any catastrophic event at the school's assets.
- ❍ Identify any critical faculty, staff, or administration whose loss would degrade, or seriously complicate the safety of students, faculty, and staff during an emergency. [Consider first responders or the personnel responsible for shelter operations at a school that is a designated shelter for natural hazards.]
- ❍ Determine if the school's assets can be replaced and identify replacement costs if the school building is lost.
- ❍ Identify the locations of key equipment.
- ❍ Determine the locations of personnel work areas and systems within a school.
- ❍ Identify the locations of any personnel operating "outside" a school's controlled areas.
- ❍ Determine, in detail, the physical locations of critical support architectures:
  - Communications and information technology (IT - the flow of critical information)
  - Utilities (e.g., facility power, water, air conditioning, etc.)
  - Lines of communication that provide access to external resources and provide movement of students and faculty (e.g., road, rail, air transportation)
- ❍ Determine the location, availability, and readiness condition of emergency response assets, and the state of training of school staff in their use.

1.1.3 Quantifying Asset Value

After a list of a school's assets or resources of value requiring protection have been identified, they should be assigned a value. Asset value is the degree of debilitating impact that would be caused by the incapacity or destruction of the school's assets.

There are many scales that can be used, each with advantages and disadvantages. Because some people are used to working with linguistic scales, although many engineers and designers prefer numerical systems, this publication will use a combination of a seven-level linguistic scale and a ten-point numerical scale as shown in Table 1-1. Obviously, the key asset for every school is its people (e.g., students, faculty, and staff). They will always be assigned the highest asset value as in the example below.

Table 1-1: Asset Value Scale

Asset Value	
Very High	10
High	8-9
Medium High	7
Medium	5-6
Medium Low	4
Low	2-3
Very Low	1

Very High – Loss or damage of the school's assets would have exceptionally grave consequences, such as extensive loss of life, widespread severe injuries, or total loss of primary services and core functions and processes.

High – Loss or damage of the school's assets would have grave consequences, such as loss of life, severe injuries, loss of primary services, or major loss of core functions and processes for an extended period of time.

Medium High – Loss or damage of the school's assets would have serious consequences, such as serious injuries, or impairment of core functions and processes for an extended period of time.

Medium – Loss or damage of the school's assets would have moderate to serious consequences, such as injuries, or impairment of core functions and processes.

Medium Low – Loss or damage of the school's assets would have moderate consequences, such as minor injuries, or minor impairment of core functions and processes.

Low – Loss or damage of the school's assets would have minor consequences or impact, such as a slight impact on core functions and processes for a short period of time.

Very Low – Loss or damage of the school's assets would have negligible consequences or impact.

Asset Value Example. A nominal list of assets for a typical high school with assigned value is presented in Table 1-2. Please note that this is a nominal example; each school should tailor its list to its own unique situation. In Section 1.4, the results of the asset value assessment will be combined with the results of a threat assessment (Section 1.2) and a vulnerability assessment (Section 1. 3) to determine total risk.

1.2 THREAT/HAZARD ASSESSMENT

After identifying asset value, the next step in the assessment process is to conduct a threat/hazard assessment wherein the threats or hazards are identified, defined, and quantified. Within the Department of Defense (DoD), intelligence community, and law enforcement, the term "threat" is typically used to describe the design criteria for terrorism or manmade disasters. Within the Federal Emergency Management Agency (FEMA) and other civil agencies, the term "hazard" is used in several different contexts. "Natural hazard" typically refers to a natural event such as an earthquake, a flood, or a wind disaster. "Manmade hazards" are "technological hazards" and "terrorism." These are distinct from natural hazards primarily in that they originate from human activity. Furthermore, "technological hazards" are generally assumed to be accidental, and their consequences are considered unintended. For the sake of simplicity, this primer will use the terms "threat" and "hazard" when referring to terrorism and manmade disasters, respectively.

Table 1-2: Nominal High School Asset Value Assessment

Asset	Value	Numeric Value
Students	Very High	10
Faculty	Very High	10
Staff	Very High	10
Designated Shelter (safe haven)	Very High	10
Main School Building	High	9
Teaching Functions	High	9
IT/Communications Systems	High	8
Utilities Associated with Shelter	Medium High	7
Utility Systems (gas, electrical, sewer/water)	Medium High	7
Nurses Station	Medium High	7
School/Student Records	Medium High	7
Transportation (buses and parking)	Medium High	7
Security Equipment (metal detectors, badge equipment)	Medium High	7
Administrative Functions	Medium	5
Temporary Classrooms (trailers)	Medium Low	4
Food Service (cafeteria/kitchen)	Medium Low	4
Library	Low	3
Custodial Functions	Low	3
Science Laboratories	Low	3
Vocational Equipment (shops)	Low	3
Indoor Sports Facilities	Low	2
Outdoor Sports Facilities	Very Low	1

For terrorism, the threat is from aggressors (those people with intent to do harm) that are known to exist, have the capability for hostile actions, and have expressed intentions for using hostile actions. They may seek publicity for their cause or political gain through their actions to injure or kill people, and destroy or damage facilities, property, equipment, or resources.

Aggressor tools can be forced entry tools, vehicles, or surveillance (visual/audio). Their weapons can be incendiary devices; small arms (rifles and handguns); stand-off military-style weapons (rocket propelled grenades or mortars); explosive devices; and CBR agents. Their tactics run the gamut: moving vehicle bombs; stationary vehicle bombs; exterior attacks (thrown objects like rocks, Molotov cocktails, hand grenades, or hand-placed bombs); stand-off weapons attacks (small arms, military or improvised direct and indirect fire weapons); covert entries (gaining entry by false credentials or circumventing security with or without weapons); mail bombs (delivered to individuals or institutions); airborne contamination (CBR agents used to contaminate the air, water, or food supply to a school); and waterborne contamination (CBR agents injected into the water supply of a school facility).

A threat assessment is a continual process of compiling and examining all available information concerning potential threats and manmade hazards. It can be broken down into two processes (1) defining threats and (2) identifying threat event profiles and tactics.

1.2.1 Threat Identification

The beginning point for security design is to define threats (hazards) and tactics that may be employed. From a physical attack viewpoint, schools maybe susceptible to attack by a number of different threats and tactics especially in areas of high risk. Schools are typically site constrained, have well defined traffic control and entry points, and operate on standard schedules. Designers and school administrators need to evaluate attack objectives, threat event profiles, and the effects or impact of the attack on the school and its occupants. It should also be noted that weapons and tactics change faster than the construction of schools. Table 1-3 provides a broad spectrum of manmade threats/hazards to consider and can be used as a tool in the threat assessment process. An extensive list of potential chemical and biological agents that can be used in terrorist attacks is provided in Appendix C. Blast range effects are indicated throughout Chapter 4.

Table 1-3: Event Profiles for Terrorism and Technological Hazards*

Threat/Hazard	Application Mode	Duration	Extent of Effects; Static/Dynamic	Mitigating and Exacerbating Conditions
Nuclear Device	Detonation of nuclear device underground, at the surface, in the air, or at high altitude.	Light/heat flash and blast/shock wave last for seconds; nuclear radiation and fallout hazards can persist for years. Electromagnetic pulse from a high-altitude detonation lasts for seconds and affects only unprotected electronic systems.	Initial light, heat, and blast effects of a subsurface, ground, or air burst are static and are determined by the device's characteristics and employment; fallout of radioactive contaminants may be dynamic, depending on meteorological conditions.	Harmful effects of radiation can be reduced by minimizing the time of exposure. Light, heat, and blast energy decrease logarithmically as a function of distance from seat of blast. Terrain, forestation, structures, etc., can provide shielding by absorbing and/or deflecting radiation and radioactive contaminants.
Biological Agent - Anthrax - Botulism - Bru cellosis - Plague - Smallpox - Tularemia - Viral Hemorrhagic Fevers - Toxins (Botulinum, Ricin, Staphylococcal Enterotoxin B, T-2 Mycotoxins)	Liquid or solid contaminants can be dispersed using sprayers/aerosol generators or by point or line sources such as munitions, covert deposits, and moving sprayers. May be directed at food or water supplies.	Biological agents may pose viable threats for hours to years, depending on the agent and the conditions in which it exists.	Depending on the agent used and the effectiveness with which it is deployed, contamination can be spread via wind and water. Infection can be spread via human or animal vectors.	Altitude of release above ground can affect dispersion; sunlight is destructive to many bacteria and viruses; light to moderate winds will disperse agents, but higher winds can break up aerosol clouds; the micro-meteorological effects of buildings and terrain can influence aerosolization and travel of agents.

Table 1-3: Event Profiles for Terrorism and Technological Hazards* (continued)

Threat/Hazard	Application Mode	Duration	Extent of Effects; Static/Dynamic	Mitigating and Exacerbating Conditions
Chemical Agent - Blister - Blood - Choking/Lung/ Pulmonary - Incapacitating - Nerve - Riot Control/Tear Gas - Vomiting	Liquid/aerosol contaminants can be dispersed using sprayers or other aerosol generators; liquids vaporizing from puddles/ containers; or munitions.	Chemical agents may pose viable threats for hours to weeks, depending on the agent and the conditions in which it exists.	Contamination can be carried out of the initial target area by persons, vehicles, water, and wind. Chemicals may be corrosive or otherwise damaging over time if not remediated.	Air temperature can affect evaporation of aerosols. Ground temperature affects evaporation of liquids. Humidity can enlarge aerosol particles, reducing the inhalation hazard. Precipitation can dilute and disperse agents, but can spread contamination. Wind can disperse vapors, but also cause target area to be dynamic. The micro-meteorological effects of buildings and terrain can alter travel and duration of agents. Shielding in the form of sheltering in place may protect students, faculty, staff, and property from harmful effects.
Radiological Agent - Alpha - Beta - Gamma	Radioactive contaminants can be dispersed using sprayers/aerosol generators, or by point or line sources such as munitions, covert deposits, and moving sprayers.	Contaminants may remain hazardous for seconds to years, depending on material used.	Initial effects will be localized to site of attack; depending on meteorological conditions, subsequent behavior of radioactive contaminants may be dynamic.	Duration of exposure, distance from source of radiation, and the amount of shielding between source and target determine exposure to radiation.
Improvised Explosive Device (Bomb) - Stationary Vehicle - Moving Vehicle - Mail - Supply - Thrown - Placed - Personnel	Detonation of explosive device on or near target; via person, vehicle, or projectile.	Instantaneous; additional secondary devices may be used, lengthening the time duration of the threat/hazard until the attack site is determined to be clear.	Extent of damage is determined by type and quantity of explosive. Effects generally static other than cascading consequences, incremental structural failure, etc.	Blast energy at a given stand-off is inversely proportional to the cube of the distance from the device; thus, each additional increment of stand-off provides progressively more protection. Exacerbating conditions include ease of access to target; lack of barriers/shielding; poor construction; and ease of concealment of device.

Table 1-3: Event Profiles for Terrorism and Technological Hazards* (continued)

Threat/Hazard	Application Mode	Duration	Extent of Effects; Static/Dynamic	Mitigating and Exacerbating Conditions
Arson/ Incendiary Attack	Initiation of fire or explosion on or near target via direct contact or remotely via projectile.	Generally minutes to hours.	Extent of damage is determined by type and quantity of device/accelerant and materials present at or near target. Effects generally static other than cascading consequences, incremental structural failure, etc.	Mitigation factors include built-in fire detection and protection systems and fire-resistive construction techniques. Inadequate security can allow easy access to target, easy concealment of an incendiary device, and undetected initiation of a fire. Non-compliance with fire and building codes as well as failure to maintain existing fire protection systems can substantially increase the effectiveness of a fire weapon.
Hazardous Material Release (fixed facility or transportation) - Toxic Industrial Chemicals and Materials (Organic vapors: cyclohexane; Acid gases: cyanogens, chlorine, hydrogen sulfide; Base gases: ammonia; Special cases: phosgene, formaldehyde)	Solid, liquid, and/or gaseous contaminants may be released from fixed or mobile containers.	Hours to days.	Chemicals may be corrosive or otherwise damaging over time. Explosion and/or fire may be subsequent. Contamination may be carried out of the incident area by persons, vehicles, water, and wind.	As with chemical weapons, weather conditions will directly affect how the hazard develops. The micro-meteorological effects of buildings and terrain can alter travel and duration of agents. Shielding in the form of sheltering in place can protect students, faculty, staff, and property from harmful effects. Non-compliance with fire and building codes as well as failure to maintain existing fire protection and containment features can substantially increase the damage from a hazardous materials release.
Armed Attack - Ballistics (small arms) - Stand-off Weapons (rocket propelled grenades, mortars)	Tactical assault or sniper attacks from a remote location.	Generally minutes to days	Varies, based upon the perpetrators' intent and capabilities.	Inadequate security can allow easy access to target, easy concealment of weapons, and undetected initiation of an attack.

Table 1-3: Event Profiles for Terrorism and Technological Hazards* (continued)

Threat/Hazard	Application Mode	Duration	Extent of Effects; Static/Dynamic	Mitigating and Exacerbating Conditions
Cyberterrorism	Electronic attack using one computer system against another.	Minutes to days.	Generally no direct effects on built environment.	Inadequate security can facilitate access to critical computer systems, allowing them to be used to conduct attacks.
Unauthorized Entry - Forced - Covert	Use of hand or power tools, weapons, or explosives to create a man-sized opening or operate an assembly (such as a locked door), or use false credentials to enter a building or simple covert entry.	Minutes to hours, depending upon the intent.	If goal is to steal or destroy physical assets or compromise information, the initial effects are quick, but damage may be long lasting. If intent is to disrupt operations or take hostages, the effects may last for a long time, especially if injury or death occurs.	Standard physical security building design should be the minimum mitigation measure. For more critical assets, additional measures, like closed circuit television (CCTV) or traffic flow that channels visitors past access control, aids in detection of this hazard.

*ADAPTED FROM: FEMA 386-7, *INTEGRATING HUMAN-CAUSED HAZARDS INTO MITIGATION PLANNING*, SEPTEMBER 2002.

1.2.2 Threat Definition

A threat (hazard) is any indication, circumstance, or event with the potential to cause loss of, or damage to an asset. It is important to understand who are the people with the intent to cause harm; or who, by process, materials, or proximity, can cause indirect harm to a school building. With the goal of reducing the potential risk of a school building, the design team and school administration should seek threat assessment information from local law enforcement, the local office of the Federal Bureau of Investigation (FBI), State Health Departments, the Department of Homeland Security (DHS), and the Homeland Security Offices (HSOs) at the state level. In many areas of the country, there are threat coordinating committees that facilitate the sharing of information. Local fire departments and hazardous materials (HazMat) units will frequently understand the threat of technological hazards due to hazardous materials on school grounds as well as those in surrounding industries that could cause a collateral threat to schools. In many jurisdictions, the HazMat unit is part of the fire department.

After information on potential aggressors is gathered, it should be analyzed. A common method to evaluate terrorist threats uses five factors: existence, capability, history, intention, and targeting.

Existence addresses the questions: Who is hostile to our school building or community of concern? Are they present or thought to be present? Are they able to enter the country or are they readily identifiable in a local community upon arrival?

Capability addresses the questions: What weapons have been used in carrying out past attacks? Do the aggressors need to bring them into the area or are they available locally?

History addresses the questions: What has the potential threat element done in the past and how many times? When was the most recent incident and where, and against what target? What tactics did they use? Are they supported by another group or individuals? How did they acquire their demonstrated capability?

Intention addresses the questions: What does the potential threat element or aggressor hope to achieve? How do we know this (e.g., published in books or news accounts, speeches, letters to the editor, informant)?

Targeting addresses the questions: Do we know if an aggressor (we may not know which specific one) is performing surveillance on our school, nearby facilities, or facilities that have much in common with our school? Is this information current and credible, and indicative of preparations for terrorist operations (manmade hazards)?

The threat/hazard analysis for a school can range from a general threat/hazard scenario shared by all members of a community to a very detailed examination of specific groups, individuals, and tactics that must be repelled or defended against by means of school design. The Homeland Security Advisory System has five threat levels that provide a general indication of risk of terrorist attack. In Table 1-4, the five factors commonly used to evaluate terrorist threats have been layered onto the Homeland Security Advisory levels. It illustrates threat levels and provides a representation of the likelihood of a terrorist attack. If the anticipated threat or projected character/use of the facility warrant, a detailed threat analysis should be developed in coordination with local law enforcement, intelligence, and civil authorities in order to more quantitatively determine the vulnerability or risk. All schools should identify actions to be taken for each threat level. A table with specific recommendations for schools based on the Homeland Security Threat Advisory Level is presented in Chapter 3 (Table 3-3).

Table 1-4: Homeland Security Threat Conditions

Threat Level	Threat Analysis Factors				
	Existence	Capability	History	Intentions	Targeting
Severe (Red)	●	●	●	●	●
High (Orange)	●	●	●	●	❏
Elevated (Yellow)	●	●	●	❏	
Guarded (Blue)	●	●	❏		
Low (Green)	●	❏			

● Factor must be present ❏ Factor may or may not be present

Please note the DHS does not use these threat analysis factors to determine threat level.

SOURCE: COMMONWEALTH OF KENTUCKY OFFICE OF HOMELAND SECURITY.

1.2.3 Threat Assessment Products

A threat assessment is a continual process of compiling and examining all available information concerning potential threats and manmade hazards. The product of a threat assessment is a list of threats and hazards with a threat rating assigned. The threat rating is a subjective judgment based on existence, capability, history, intention, and targeting. Often, information is sketchy and analysts must rely more on the judgment of experts, statistical probability, and occasionally assumptions to help quantify and qualify the threat (all assumptions should be documented). The same combination of linguistic scale and numerical scale used in the asset value assessment (Table 1-1) can be used for the threat assessment as presented in Table 1-5. Assessing terrorist threats is much more difficult than assessing the risk from natural hazards such as earthquakes, floods, and winds. Historical data form the basis of threat and locality indicates vulnerability to a great extent in regard to natural hazards. For terrorist threats, the likelihood of occurrence is less defined and the associated vulnerabilities have many considerations that impact making good risk management decisions.

Table 1-5: Threat Rating Scale

Threat Rating	
Very High	10
High	8-9
Medium High	7
Medium	5-6
Medium Low	4
Low	2-3
Very Low	1

Very High – Known aggressors or hazards, highly capable of causing loss of, or damage to the school exist. One or more vulnerabilities are present. The aggressors are known or highly suspected of having intent to exploit the school's assets and are known or highly suspected of performing surveillance on a facility.

High – Known aggressors or hazards, capable of causing loss of, or damage to the school exist. One or more vulnerabilities are present and the aggressors are known or reasonably suspected of having intent to exploit the school's assets.

Medium High – Known aggressors or hazards, capable of causing loss of, or damage to the school exist. One or more vulnerabilities are present and the aggressor is suspected of having intent to exploit the school's assets.

Medium – Known aggressors or hazards that may be capable of causing loss of, or damage to the school exist. One or more vulnerabilities may be present; however, the aggressors are not believed to have intent to exploit the school's assets.

Medium Low – Known aggressors or hazards that may be capable of causing loss of or damage to the school exist. Aggressors have no intent to exploit the school's assets.

Low – Few or no aggressors or hazards exist. Their capability of causing damage to the school's assets is doubtful.

Very Low – No aggressors or hazards exist.

Threat Assessment Example. A nominal list of threats/hazards with assigned threat rating is presented in Table 1-6. Please note that this is a nominal example; each school should tailor its list to its own unique situation.

Table 1-6: Nominal High School Threat Assessment

Threat/Hazard	Threat Rating	Numeric Threat Rating
Stationary vehicle bomb	Low	2
Attack with small arms	Medium Low	4
Hydrogen sulfide "stink bomb"	Medium	5
Forced entry at night to damage school property	Medium High	7
Electronic attack to destroy or alter school academic records	Medium High	7

1.2.4 Design Basis Threat

Traditionally, the building regulatory system has addressed natural disaster mitigation (hurricane, tornado, flood, earthquake, windstorm, and snow storm) through prescriptive building codes supported by well-established and accepted reference standards, regulations, inspection, and assessment techniques. Some manmade risks (e.g., HazMat storage) and specific societal goals (energy conservation and life safety) have also been similarly addressed. However, the building regulation system has not yet fully addressed most manmade hazards or terrorist threats.

Soon after September 11, 2001, the New York City Building Department initiated an effort to analyze the building code in relation to terrorist threats. The task force issued a report recommending code changes based on the attack on the World Trade Center. The National Fire Protection Association (NFPA) has a committee on premises security and security system installation standards. These advancements may some day result in the building regulatory system developing prescriptive building codes to mitigate security threats.

In the absence of such regulations, identifying design basis threats (e.g., threat tactics, weapons, tools, or explosives against which a building must be protected) should be considered as part of a school's threat assessment to facilitate the work of designers during new construction or rehabilitation of an existing school building. The DoD, General Services Administration (GSA), and Department of State (DOS) all have established processes to identify design basis threats for their facilities.

The typical building design and construction process is sequential, progressing from identifying building use and design goals through actual construction. This process is illustrated in Figure 1-2.

Figure 1-2 Typical building design and construction process

In every school design and renovation project, there are ultimately three choices of how to address the risk posed by terrorism:

1. Do nothing and accept the risk
2. Perform a risk assessment and manage the risk by installing reasonable mitigation measures to achieve a desired level of protection
3. Harden the building against all threats to achieve the least amount of risk

Figure 1-3 is a graphical representation of the three choices. Since September 11, 2001, terrorism has become a dominant concern. Life, safety, and security issues should be a design goal from the beginning for all schools.

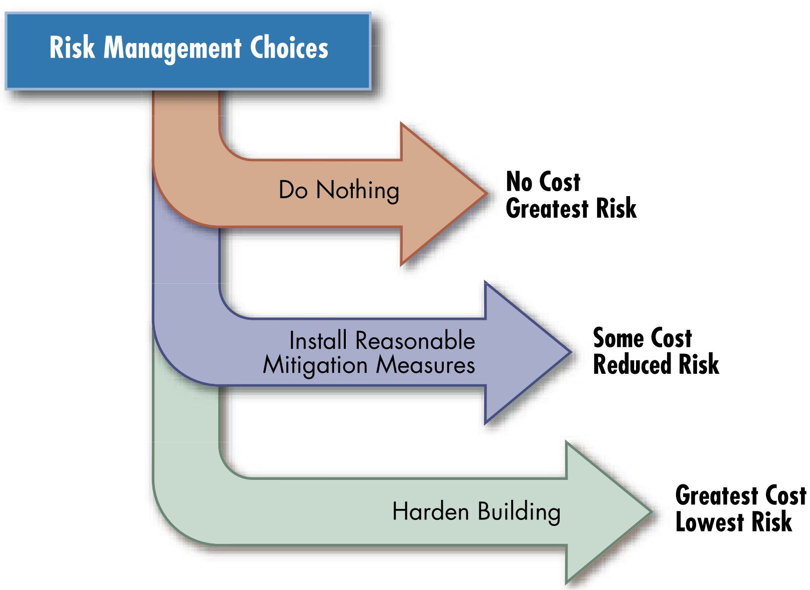


Figure 1-3 Risk management choices

1.3 VULNERABILITY ASSESSMENT

A vulnerability assessment evaluates vulnerability, or any weaknesses that can be exploited by an aggressor, of critical assets across a broad range of identified threats and provides a basis for determining mitigation measures for protection of people and critical assets.

The Building Vulnerability Assessment Checklist provided in Appendix F is based on the checklist developed by the Department of Veterans Affairs (VA) and compiles many best practices based upon technologies and scientific research to consider during the design of a new building or an assessment of an existing school building. It allows a consistent security evaluation of designs at various levels. The checklist can be used as a screening tool for an initial vulnerability assessment or be used by subject matter experts for a comprehensive vulnerability assessment of existing school buildings.

The assessment of any vulnerability of a school building should be done within the context of the defined threats and the value of the school's assets. That is, each element of the school building should be analyzed for vulnerabilities to each threat and a vulnerability rating should be assigned. The same combination of linguistic scale and numerical scale used in the asset value and threat assessments (Tables 1-1 and 1-5) can also be used for the vulnerability assessment as presented in Table 1-7. It should be noted that a vulnerability assessment may change the value rating of assets due to the identification of critical nodes or some other factor that makes the school's assets more valuable.

Table 1-7: Vulnerability Rating Scale

Vulnerability Rating	
Very High	10
High	8-9
Medium High	7
Medium	5-6
Medium Low	4
Low	2-3
Very Low	1

Very High – One or more major weaknesses have been identified that make the school's assets extremely susceptible to an aggressor or hazard.

High – One or more significant weaknesses have been identified that make the school's assets highly susceptible to an aggressor or hazard.

Medium High – An important weakness has been identified that makes the school's assets very susceptible to an aggressor or hazard.

Medium – A weakness has been identified that makes the school's assets fairly susceptible to an aggressor or hazard.

Medium Low – A weakness has been identified that makes the school's assets somewhat susceptible to an aggressor or hazard.

Low – A minor weakness has been identified that slightly increases the susceptibility of the school's assets to an aggressor or hazard.

Very Low – No weaknesses exist.

Vulnerability Assessment Example. To create the vulnerability assessment of a school, a site vulnerability assessment should be performed using the checklist in Appendix F. The results of the vulnerability assessment are then analyzed in conjunction with the results of the asset value and threat assessments developed earlier. Each asset/threat pair is then assigned a vulnerability rating as shown in Table 1-8 and forms the basis for identifying measures to mitigate threat vulnerability and improve protection of the building and its occupants. Please note that this is a nominal example; each school should tailor its list to its own unique situation.

Table 1-8: Nominal High School Vulnerability Assessment

	THREAT/HAZARD									
	Terrorist Act		Armed Attack		Unauthorized Entry		Low Level CBR Attack		Cyber-terrorism	
	Stationary Vehicle Bomb		Attack by Small Arms		Forced Entry at Night to Damage School Property		Hydrogen Sulfide "Stink Bomb"		Electronic Attack to Destroy or Alter School Academic Records	
ASSET	Vulnerability Rating		Vulnerability Rating		Vulnerability Rating		Vulnerability Rating		Vulnerability Rating	
Students	VH	10	H	9	VL	1	MH	7	VL	1
Faculty	VH	10	H	9	VL	1	MH	7	ML	4
Staff	VH	10	H	9	ML	4	MH	7	ML	4
Designated Shelter (safe haven)	H	9	L	3	ML	4	L	3	VL	1
Main School Building	VH	10	ML	4	M	5	L	3	VL	1
Teaching Functions	VH	10	VH	10	ML	4	H	9	L	3
IT/Communications Systems	VH	10	M	5	MH	7	L	2	MH	7
Utilities Associated with Shelter	H	8	ML	4	L	2	VL	1	VL	1
Utility Systems (gas, electrical, sewer/water)	MH	7	ML	4	M	5	L	2	VL	1
Nurses Station	H	9	H	8	M	6	L	3	VL	1
School/Student Records	H	9	L	3	M	6	L	2	MH	7
Transportation (buses and parking)	VH	10	H	9	M	6	L	3	VL	1
Security Equipment (metal detectors, badge equipment)	H	9	MH	7	M	6	L	2	VL	1
Administrative Functions	VH	10	H	8	M	6	MH	7	M	5
Temporary Classrooms (trailers)	VH	10	VH	10	MH	7	ML	4	VL	1
Food Service (cafeteria/kitchen)	VH	10	H	8	M	5	MH	7	VL	1
Library	VH	10	VH	10	MH	7	MH	7	ML	4
Custodial Functions	VH	10	ML	4	M	6	ML	4	VL	1
Science Laboratories	VH	10	M	5	H	8	L	3	VL	1
Vocational Equipment (shops)	VH	10	ML	4	H	8	L	3	VL	1
Indoor Sports Facilities	VH	10	ML	4	H	8	M	6	VL	1
Outdoor Sports Facilities	M	5	L	2	MH	7	L	2	VL	1

VH = Very High; H = High; MH = Medium High; M = Medium; ML = Medium Low; L = Low; VL = Very Low

1.4 RISK ASSESSMENT

Risk is the potential for a loss of or damage to an asset. It is measured based upon the value of the asset in relation to the threats and vulnerabilities associated with it. Risk is based on the likelihood or probability of the hazard occurring and the consequences of the occurrence. A risk assessment analyzes the threat (probability of occurrence), and asset value and vulnerabilities (consequences of the occurrence) to ascertain the level of risk for each asset against each applicable threat/hazard. Thus, a very high likelihood of occurrence with very small consequences may require simple, low cost mitigation measures, but a very low likelihood of occurence with very grave consequences may require more costly and complex mitigation measures. The risk assessment provides engineers, architects, and school administrators with a relative risk profile that defines which assets are at the greatest risk against specific threats. Chapters 2 and 3 explore mitigation measures to reduce the vulnerability and risk for valuable assets with a high risk.

There are numerous methodologies and techniques for conducting a risk assessment. One approach is to assemble the results of the asset value assessment, threat assessment, and vulnerability assessment, and determine a numeric value of risk for each asset and threat/hazard pair in accordance with the following formula:

Risk = Asset Value x Threat Rating x Vulnerability Rating

The completed matrix provides a quantitative value for risk that can be converted into a linguistic value as shown in Table 1-9. The following rating system can be used for assessing the risk of schools.

Table 1-9: Risk Rating System

Risk	Risk Rating
≥ 261	Very High
201 - 260	High
141 - 200	Medium High
101 - 140	Medium
61 - 100	Medium Low
31 - 60	Low
1 - 30	Very Low

Very High – The potential for loss or damage of the school's assets is so great as to expect exceptionally grave consequences, such as extensive loss of life, widespread severe injuries, or total loss of primary services, and core functions and processes.

High – The potential for loss or damage of the school's assets is so great as to expect grave consequences, such as loss of life, severe injuries, loss of primary services, or major loss of core functions and processes for an extended period of time.

Medium High – The potential for loss or damage of the school's assets is such as to expect serious consequences (e.g., as serious injuries, or impairment of core functions and processes for an extended period of time).

Medium – The potential for loss or damage of the school's assets is such as to expect serious consequences (e.g., injuries, or impairment of core functions and processes).

Medium Low – The potential for loss or damage of the school's assets is such as to expect only moderate consequences (e.g., minor injuries, or minor impairment of core functions and processes).

Low – The potential for loss or damage of the school's assets is such as to expect only minor consequences or impact (e.g., a slight impact on core functions and processes for a short period of time).

Very Low – The potential for loss or damage of the school's assets is so low that there would only be negligible consequences or impact.

Because of the large amount of information in a risk assessment matrix, it is useful to assign a color code (red, yellow, or green) based on the total numeric value of risk determined based on the scale in Table 1-10.

Table 1-10: Risk Color Value System

	Low Risk	Medium Risk	High Risk
Risk Factors Total	1-60	61-175	≥ 176

As a minimum, mitigation measures to reduce risk and create an acceptable level of protection should be considered for those critical assets determined to be at highest risk.

Risk Assessment Example. A nominal risk assessment is presented in Table 1-11 based on the asset value, threat, and vulnerability assessment examples presented earlier. As mentioned previously, each school should tailor its list to its own unique situation.

Table 1-11: Nominal High School Risk Assessment Matrix

	Threat/Hazard				
	Terrorist Act	**Armed Attack**	**Unauthorized Entry**	**Low Level CBR Attack**	**Cyber-terrorism**
	Stationary Vehicle Bomb	Attack by Small Arms	Forced Entry at Night to Damage School Property	Hydrogen Sulfide "Stink Bomb"	Electronic Attack to Destroy or Alter School Academic Records
Students/Faculty/Staff	200	360	50	490	140
Asset Value Rating	10	10	10	10	10
Threat Rating	2	4	5	7	7
Vulnerability Rating	10	9	1	7	2
Designated Shelter (safe haven)	180	120	200	210	70
Asset Value Rating	10	10	10	10	10
Threat Rating	2	4	5	7	7
Vulnerability Rating	9	3	4	3	1
Main School Building	180	144	225	189	63
Asset Value Rating	9	9	9	9	9
Threat Rating	2	4	5	7	7
Vulnerability Rating	10	4	5	3	1
Teaching Functions	60	120	60	189	63
Asset Value Rating	3	3	3	3	3
Threat Rating	2	4	5	7	7
Vulnerability Rating	10	10	4	9	3
IT/Communications Systems	160	160	280	112	392
Asset Value Rating	8	8	8	8	8
Threat Rating	2	4	5	7	7
Vulnerability Rating	10	5	7	2	7
Utilities Associated with Shelter	112	112	70	49	49
Asset Value Rating	7	7	7	7	7
Threat Rating	2	4	5	7	7
Vulnerability Rating	8	4	2	1	1
Utility Systems (gas, electrical, sewer/water)	98	112	175	98	49
Asset Value Rating	7	7	7	7	7
Threat Rating	2	4	5	7	7
Vulnerability Rating	7	4	5	2	1
Nurses Station	126	224	210	147	49
Asset Value Rating	7	7	7	7	7
Threat Rating	2	4	5	7	7
Vulnerability Rating	9	8	6	3	1

Table 1-11: Nominal High School Risk Assessment Matrix (continued)

		Threat/Hazard				
		Terrorist Act	**Armed Attack**	**Unauthorized Entry**	**Low Level CBR Attack**	**Cyber-terrorism**
		Stationary Vehicle Bomb	Attack by Small Arms	Forced Entry at Night to Damage School Property	Hydrogen Sulfide "Stink Bomb"	Electronic Attack to Destroy or Alter School Academic Records
School/Student Records		126	84	210	98	343
	Asset Value Rating	7	7	7	7	7
	Threat Rating	2	4	5	7	7
	Vulnerability Rating	9	3	6	2	7
Transportation (buses and parking)		140	252	210	147	49
	Asset Value Rating	7	7	7	7	7
	Threat Rating	2	4	5	7	7
	Vulnerability Rating	10	9	6	3	1
Security Equipment (metal detectors, badge equipment)		126	196	210	98	49
	Asset Value Rating	7	7	7	7	7
	Threat Rating	2	4	5	7	7
	Vulnerability Rating	9	7	6	2	1
Administrative Functions		100	160	150	245	175
	Asset Value Rating	5	5	5	5	5
	Threat Rating	2	4	5	7	7
	Vulnerability Rating	10	8	6	7	5
Temporary Classrooms (trailers)		80	160	140	112	28
	Asset Value Rating	4	4	4	4	4
	Threat Rating	2	4	5	7	7
	Vulnerability Rating	10	10	7	4	1
Food Service (cafeteria/kitchen)		80	128	100	196	28
	Asset Value Rating	4	4	4	4	4
	Threat Rating	2	4	5	7	7
	Vulnerability Rating	10	8	5	7	1
Library		60	120	105	147	84
	Asset Value Rating	3	3	3	3	3
	Threat Rating	2	4	5	7	7
	Vulnerability Rating	10	10	7	7	4
Custodial Functions		60	48	90	84	21
	Asset Value Rating	3	3	3	3	3
	Threat Rating	2	4	5	7	7
	Vulnerability Rating	10	4	6	4	1

Table 1-11: Nominal High School Risk Assessment Matrix (continued)

	Threat/Hazard				
	Terrorist Act	**Armed Attack**	**Unauthorized Entry**	**Low Level CBR Attack**	**Cyber-terrorism**
	Stationary Vehicle Bomb	Attack by Small Arms	Forced Entry at Night to Damage School Property	Hydrogen Sulfide "Stink Bomb"	Electronic Attack to Destroy or Alter School Academic Records
Science Laboratories	60	60	120	63	21
Asset Value Rating	3	3	3	3	3
Threat Rating	2	4	5	7	7
Vulnerability Rating	10	5	8	3	1
Vocational Equipment (shops)	60	48	120	63	21
Asset Value Rating	3	3	3	3	3
Threat Rating	2	4	5	7	7
Vulnerability Rating	10	4	8	3	1
Indoor Sports Facilities	40	32	80	84	14
Asset Value Rating	2	2	2	2	2
Threat Rating	2	4	5	7	7
Vulnerability Rating	10	4	8	6	1
Outdoor Sports Facilities	10	8	35	14	7
Asset Value Rating	1	1	1	1	1
Threat Rating	2	4	5	7	7
Vulnerability Rating	5	2	7	2	1

1.5 THE RISK MANAGEMENT PROCESS

Risk management is the process of selecting and implementing mitigation measures to achieve an acceptable level of risk at an acceptable cost. Because it is cost-prohibitive to protect against the entire range of possible threats, it is important to develop a realistic prioritization of mitigation measures. When considering mitigation measures, the following factors should be considered:

- ❍ Results of the risk assessment, including asset value and asset vulnerabilities
- ❍ Costs of the mitigation measures

- The value of risk reduction to the school
- Frequency with which the benefits of the mitigation measures will be realized
- The deterrence or preventive value of the mitigation measures
- The expected lifespan of the mitigation measures and the time value of money

To evaluate prospective mitigation measures, the design team should first calculate new values of risk based on how the installation or use of mitigation measures would change vulnerability and/or asset values. Some mitigation measures will affect multiple asset/threat risk values. After the amount of risk reduction each mitigation measure will produce has been calculated, the cost of each mitigation measure should be estimated using resources such as R.S. Means Construction Cost Data. The final step is to perform a benefit/cost analysis to determine which mitigation measures will produce the greatest reduction of risk at an acceptable cost.

When dealing with manmade hazards and terrorism, it is much more difficult to predict how often an event will occur and the deterrent value of mitigation measures. Although there are historical data to help predict how often natural hazards such as floods or tornadoes occur in various regions, the probability or frequency of manmade hazards/threats is not known. Therefore, subjective approaches for frequency must be combined with quantitative estimates of cost-effectiveness.

Additionally, the deterrent or preventive value of a mitigation measure is also difficult to quantify. Deterrence, in the case of terrorism, may also have a secondary impact in that, once a school is "hardened," a terrorist may turn to a less protected building, changing the likelihood of an attack for both targets. For example, the Murrah Federal Building in Oklahoma City became the target of an aggressor when he was deterred from attacking his primary target, the FBI building, because it was too difficult to get the attack vehicle close to the target. He was able to park immediately adjacent to the Murrah Federal Building and successfully target the Bureau of Alcohol, Tobacco, and Firearms (ATF).

All these factors should be considered when calculating the value of mitigation measures, and weighing their value against their cost. Ideally, sufficient resources would be available to achieve a desired level of protection against design basis threats through mitigation measures. This is not always the case, so it is also important that every school identify or designate an appropriate authority that is authorized to accept risk on behalf of the school. Sometimes when decisions are left up to committees or personnel at an inappropriate level, poor choices or decisions can be made.

It is also essential to maintain analytic integrity and objectivity during the assessment process in order to achieve an honest and unbiased risk assessment. Legitimate differences of professional opinion may occur; therefore, it is also important that the process be transparent and repeatable. For example, there could be an honest disagreement about the threat rating assigned to an "electronic attack to destroy school records." An open and repeatable methodology facilitates healthy debate to help the risk acceptance authority, who is ultimately responsible, make informed decisions.

In sum, the risk management process is a benefit/cost analysis to decide and prioritize which mitigation measures to implement to achieve the desired level of protection with available resources. This is accomplished by repeating risk assessment calculations adjusting for how mitigation measures change a school's asset values and vulnerabilities. As pointed out earlier, mitigation measures may also change how an aggressor views a school, thus changing the threat assessment as well.

SITE AND LAYOUT DESIGN GUIDANCE 2

This chapter discusses comprehensive architectural and engineering design considerations (mitigation measures) for the school site, from the property line to the school building, including: land use, site planning, stand-off distance, controlled access zones, entry control and vehicular access, signage, parking, loading docks and service access, physical security lighting, and site utilities. The intent of this guidance is to provide concepts for integrating mitigation strategies to the design basis threats as identified during the risk assessment. Integrating security requirements into a larger, more comprehensive approach necessitates achieving a balance among many objectives such as reducing risk; facilitating proper school building function; aesthetics and matching architecture; creating a school environment conducive to learning; and hardening of physical structures beyond required building codes and standards for added security.

The design community must work closely with school districts and school administrators to ensure that the optimal balance of all these considerations is achieved; thus, coordination within the design team is critical. Many school asset protection objectives can be achieved during the early stages of the design process when mitigation measures are the least costly and most easily implemented. Planners, architects, and landscape designers play an important role in identifying and implementing crucial asset protection measures while considering land use; site selection; the orientation of buildings on the site; and the integration of vehicle access, control points, physical barriers, landscaping, parking, and protection of utilities to mitigate threats.

It is important to remember that the nature of any threat is always changing. Although indications of potential future threats may be scarce during the design stage, consideration should be given to accommodating enhanced protection measures in response to future threats that may emerge. School protection objectives must be balanced with other design objectives, such as the efficient use of land and resources, and must also take into account existing physical, programmatic, and fiscal constraints.

2.1 LAND USE CONSIDERATIONS

Land use is a broad planning process that encompasses zoning ordinances, subdivision regulations, and master planning. Regulating land use development has been a common practice in the United States for many years, with numerous regulations and other tools in use by state and local governments to influence the configuration of urban sites. Comprehensive planning can encourage certain types of development, incentives, allocation of resources, and capital improvement programs oriented to improve the security of areas vulnerable to manmade disasters. In most cases, sound site planning will increase the land area needed for individual school buildings and maximize the protection measures to be adopted. Other potential terrorist targets in the surrounding area should also be considered. Students and teachers might be killed or injured by collateral damage from a terrorist attack directed at another nearby facility. When designing a school, the designer should consider external and internal land use design concerns, including the characteristics of the surrounding area (e.g., construction type, occupancies, and the nature and intensity of adjacent activities), as well as the implications of these characteristics for the protection of the students, faculty, and staff on the school site under consideration. The amount of land available on the site for stand-off and the inherent ability of the school site to accommodate the implementation of natural and manmade antiterrorism and security design features could help the designers to determine if other measures such as hardening the school building should also be considered.

It is important to recognize that conflicts sometimes arise between security-oriented site design and conventional site design. For example, open circulation and common spaces (which are desirable for conventional design) may be detrimental to certain aspects of security.

When designing new school buildings or evaluating existing schools, the designer should evaluate key protection measures to ensure they are appropriate, desirable, and cost-effective in terms of mitigating the risk of potential terrorist attacks. Security measures must be evaluated carefully to understand which measures are truly beneficial and which are not practical.

When making decisions about site antiterrorism and security, designers should consider the following:

- ❍ Adjacent land use and zoning plans for potential development that would impact security within the school (assess by using land use maps and Geographic Information Systems [GISs])
- ❍ Building footprint(s) relative to total land available
- ❍ Building location(s) or, if undeveloped, suitable building location(s) relative to the site perimeter and adjacent land uses; distance between the perimeter fence and improved areas off site
- ❍ Access via foot, road, rail, water, and air; suitability to support a secure perimeter
- ❍ Current and planned infrastructure and its vulnerabilities, including easements, tunnels, pipes, and rights-of-way
- ❍ Infrastructure nodes that constitute single-point vulnerabilities
- ❍ Adjacent land uses and occupancies that could enable or facilitate attacks or that are potential targets themselves and thus present collateral damage or cascading failure hazards
- ❍ Proximity to fire and police stations, hospitals, shelters, and other critical facilities that could be of use in an attack
- ❍ Presence of natural physical barriers such as water features, dense vegetation, and terrain that could provide access control and/or shielding, or suitability of the site for the incorporation of such features
- ❍ Topographic and climatic characteristics that could affect the performance of chemical agents and other weapons

- Observability from outside site boundaries; ability of vegetation in proximity to building or site to screen covert activity

2.2 SITE PLANNING

The single most important goal in planning a site to resist terrorism and security threats is the protection of life, property, and operations. Decision-making in support of this purpose should be based first and foremost on a comprehensive assessment of the manmade threats and hazards so that planning and design countermeasures are appropriate and effective in the reduction of vulnerability and risk as described in Chapter 1. It is important to recognize that a given countermeasure can mitigate one or more vulnerabilities, but may be detrimental to other important design goals. This section will highlight several aspects of site design and will present some of the unique characteristics arising from their application to antiterrorism and security.

2.2.1 Site Design

Because the economics of development dictate the construction of schools, security concerns should be evaluated carefully. Conflicts sometimes arise between security site design and conventional site design. For example, open circulation and common spaces, which are desirable for conventional school design, are often undesirable for security design. To maximize safety, security, and sustainability, designers should implement a holistic approach to site design that integrates form and function to achieve a balance among the various design elements and objectives. Even if resources are limited, significant value can be added to a project by integrating security considerations into the more traditional design tasks in such a way that they complement, rather than compete with, the other elements.

2.2.2 Layout and Form

The overall layout of a school site (e.g., the placement and form of its buildings, infrastructures, and amenities) is the starting point for development. Choices made during this stage of the design process will steer decision-making for the other elements of the site. A number of aspects of site layout and building type present security considerations and are discussed below.

- **Clustered versus dispersed functions.** There is a strong correlation between building functions and building layout and forms. Typically, the former dictates the other two. Depending on the site characteristics, the occupancy requirements, and other factors, school buildings may cluster key functions in one particular area or have these functions designed in a more dispersed manner. Both patterns have compelling strengths and weaknesses in terms of security.

  Concentrating key functions in one place may create a target-rich environment and increase the risk of collateral impacts. Additionally, it increases the potential for the establishment of more single-point vulnerabilities, such as indicated in Figure 2-1. This figure shows several key functions grouped in a particular area of the building (i.e., the mechanical rooms, stairs, telephone switch room, and loading docks). If these areas become a target, the school may be closed for a substantial period of time, even if the attack is not severe and the rest of the school remains unharmed. However, grouping high-risk activities, concentrations of personnel, and critical functions into a cluster can help maximize stand-off from the perimeter and create a "defensible space." This also helps to reduce the number of access and surveillance points, and minimize the size of the perimeter needed to protect the school areas.

  In contrast, the dispersal of key functions reduces the risk that an attack on any one part of the site will impact the other parts. However, this could also have an isolating effect and reduce the effectiveness of on-site surveillance, increase the complexity of security systems and emergency response, and create a less defensible space.

  To the extent that site, economic, and other factors allow, the designer should consolidate school designs that are functionally

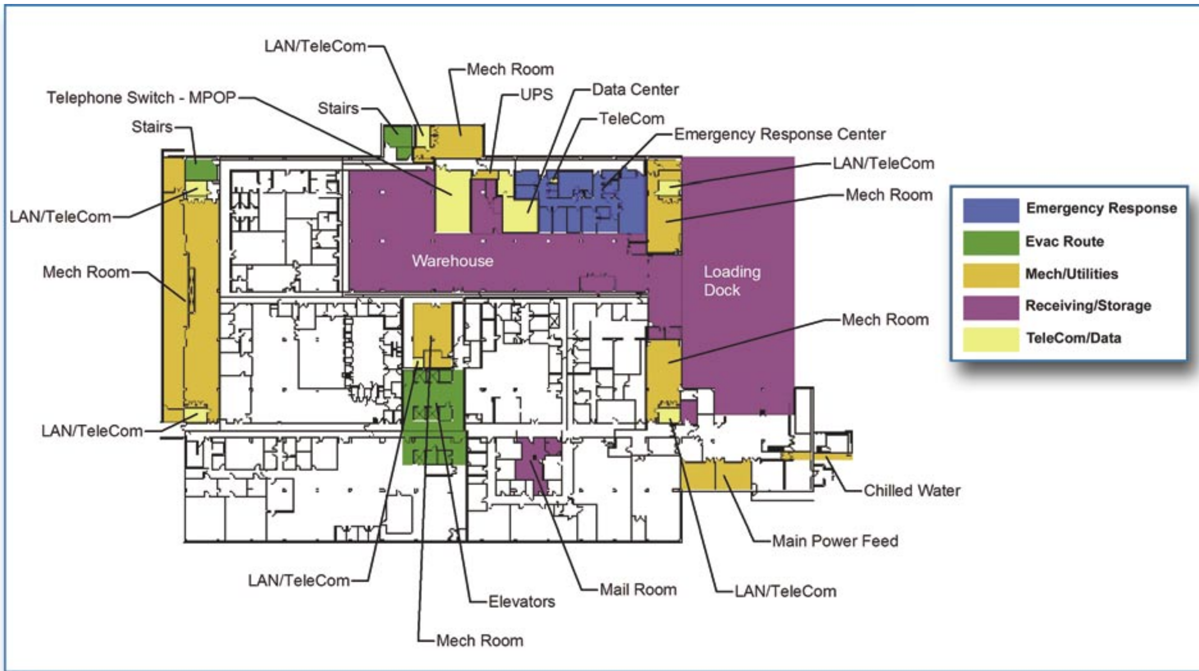
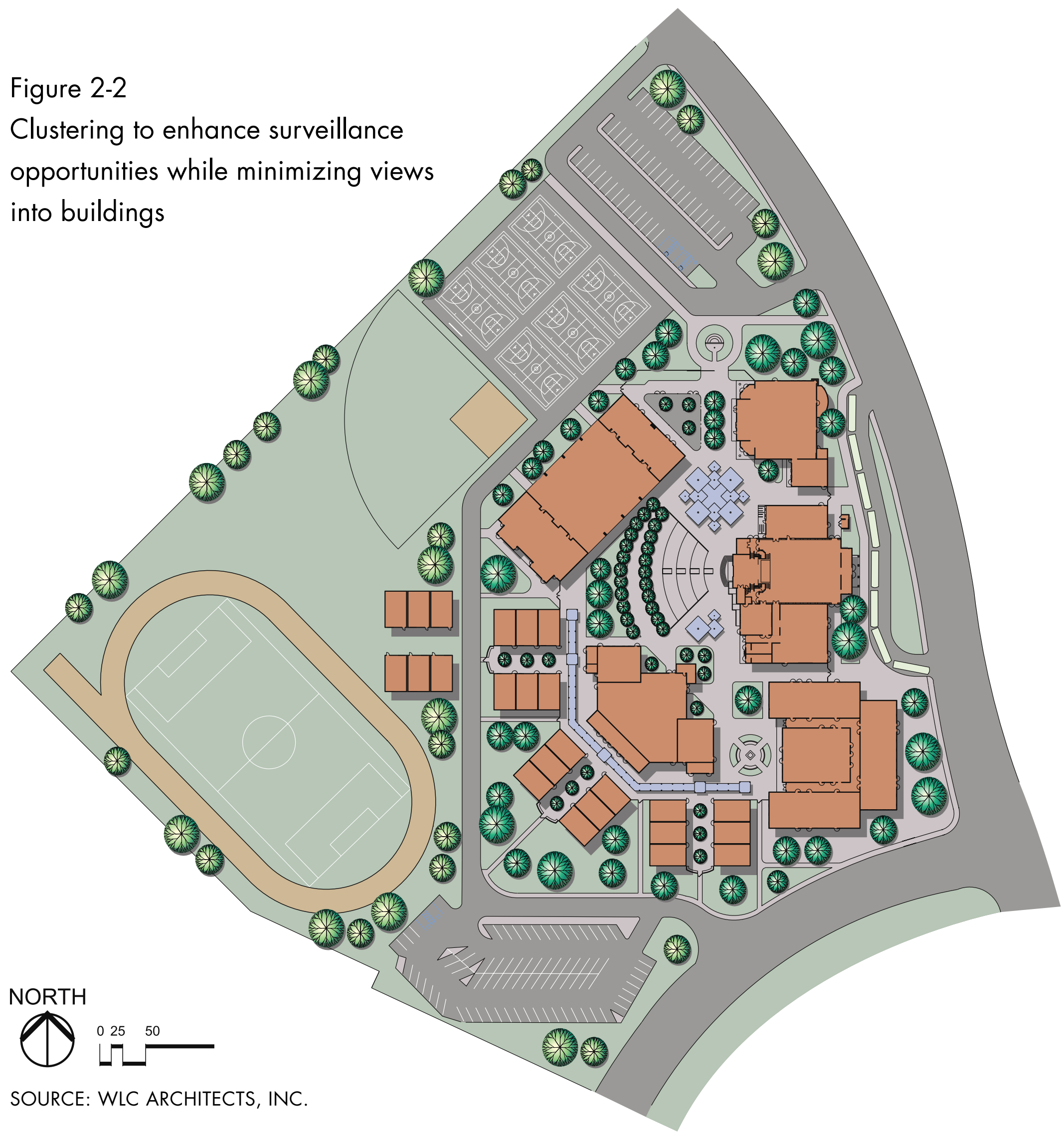


Figure 2-1 Non-redundant critical functions collocated near loading dock

compatible and have similar threat levels. For example, visitor areas and receiving/loading areas constitute a school's innermost line of defense, because they are the first places where people and materials enter the school building. Logically, they should be physically separated from other key functions such as the main operational areas or where people concentrate.

- **School building orientation.** The orientation of a school building can have significant impact on its performance, not only in terms of energy efficiency, but also the ability to protect occupants (see Figure 2-2). A school building's orientation relative to its surroundings defines its relationship to that area. In aesthetic terms, a school building can open up to the area or turn its back; it can be inviting to those outside, or it can "hunker down" defensively. The physical positioning of a building relative to its surroundings may seem more subtle, but can be a greater determinant of this intangible quality than exterior aesthetics. Nevertheless, the proximity of a vulnerable façade to a parking area, street, adjacent site, or other area that is accessible to vehicles and/or difficult to observe can greatly contribute to its vulnerability. This illustrates one way in which protective requirements can be at odds with otherwise good design. A strong, blank wall with no glazing will help to protect students, faculty, staff, property, and operations within from a blast, but the lack of windows removes virtually all opportunity for the faculty and staff to monitor activities outside and take appropriate protective actions in a timely manner. Designers should consider such trade-offs early in the design process, in an effort to determine an acceptable level of risk.

Figure 2-2
Clustering to enhance surveillance opportunities while minimizing views into buildings



SOURCE: WLC ARCHITECTS, INC.

- **Open space.** The incorporation of open space into school site design presents a number of benefits. First and foremost is the ability to easily monitor an area and detect intruders, vehicles, and weapons. Closely related to this benefit is the stand-off value of open space; as discussed in Chapter 4, blast energy decreases as the inverse of the cube of the distance from the seat of the explosion, so every additional increment of distance provides increasingly more protection. In addition, pervious open space allows stormwater to percolate back into the ground, reducing the need for culverts, drainage pipes, manholes, and other covert site access and weapon concealment opportunities. Also, if the open space is impassible for vehicles (as in the case of a wetland or densely vegetated area), it can provide not only environmental and aesthetic amenities, but prevent vehicle intrusion as well.

- **Infrastructure and lifelines.** Providing power, gas, water, wastewater, and communications services is one of the most basic requirements of any school development. At the site scale, all critical lifelines should have at least one layer of redundancy, or backup. By eliminating single-point vulnerabilities, designers will reduce the chance that service will be interrupted if an attack damages or destroys a lifeline either outside the school perimeter or on site. It is important to note that collocating a backup lifeline with its primary lifeline does not eliminate single-point vulnerability; only physical separation can substantially increase the likelihood of continuity of service.

  Additionally, all controls, interconnections, exposed lines, and other vulnerable elements of school infrastructure systems should be protected from access and exploitation by surveillance and/or physical countermeasures. Service entrances and other secondary access points should be monitored and access-controlled; special attention should also be paid to any locations where multiple systems or primary and backup systems come together, such as control rooms and mechanical spaces. Again, these facilities should be designed for maximum observability, including the use of opportunity reduction and target hardening strategies where appropriate, and should be equipped with adequate lighting and emergency communications capabilities wherever possible. For additional information, see Sections 2.9 and 2.10.

2.2.3 Vehicular and Pedestrian Circulation

The movement of people and materials into, through, and out of a school facility is determined by the design of its access, circulation, and parking systems. Such systems should be designed to maximize efficiency while minimizing conflicts between vehicle and pedestrian modes. Designers should begin with an understanding of the school's transportation requirements based on an analysis of how the school will be used. This includes studying the number and types of access points that are required, bus requirements, the parking volume needed, where users need to go to and from, and the modes of transportation they will use. Several aspects of transportation planning can impact security and are discussed below.

- **Roadway network design.** Streets are generally designed to minimize travel time and maximize safety, with the end result typically being a straight path between two or more endpoints. Although a straight line may be the most efficient course, designers should use caution when orienting streets relative to school buildings requiring high protection. Designers should design a roadway system to minimize vehicle velocity, thus using the roadway itself as a protective measure. This is accomplished through the use of several strategies.

  First, straight-line or perpendicular approaches to school buildings should not be used in a school at high risk, because these give vehicles the opportunity to gather the speed necessary to ram through protective barriers and crash into or penetrate buildings. Instead, approaches should be parallel to the façade, with berms, high curbs, appropriate trees, or other measures used to prevent vehicles from departing the roadway. A related technique for reducing vehicle speeds is the construction of serpentine (curving) roadways with tightradius corners. Existing streets can be retrofitted with barriers, bollards, swing gates, or other measures to force vehicles to travel in a serpentine path. Again, high curbs and other measures should be installed to keep vehicles from departing the roadway in an effort to avoid these countermeasures.

Less radical than these techniques are traffic calming strategies, which seek to use design measures to cue drivers as to the acceptable speed for an area. These include raised crosswalks, speed humps and speed tables, pavement treatments, bulbouts, and traffic circles. In addition to creating a more pedestrian-friendly environment, which increases "eyes on the street" surveillance, designing roadways to physically limit speeds can have the added benefits of increasing safety and, subsequently, lowering liability. Designers should be aware, however, that many of these techniques can have detrimental effects for emergency response, including slowing response time, interfering with en route emergency medical treatment, and increasing the difficulty of maneuvering fire apparatus. They also may present problems for snow removal, and their outer ends should remain flat so that bicycles can proceed unimpeded.

- **Parking.** Surface lots can be designed and placed to keep vehicles away from school buildings, but they can consume large amounts of land and, if constructed of impervious materials, can contribute greatly to stormwater runoff. They can also be hazardous for pedestrians if dedicated pedestrian pathways are not provided. For additional information, see Section 2.7.

2.2.4 Landscape and Urban Design

Designing to meet user needs while maintaining stewardship of the natural and built environments becomes increasingly more challenging when security requirements are factored in. Design principles at the school site should include an emphasis on selection of low-impact development techniques and environmental stewardship; compatibility of context and relationship with adjacent uses, forms, and styles; establishment of scale and identity through aesthetic design; connectivity among buildings, uses, activities, and transportation modes; resource conservation; cultural responsiveness; and the creation of appealing public spaces. These objectives are generally achieved through the work of two closely related disciplines, landscape design and urban design. For the purposes of this document, these two disciplines are virtually overlapping and will, therefore, be addressed together.

- **Landscape design.** Many landscape features can be used in school design to enhance security. Landscape design features should be used to create the level of protection without turning the school into a fortress. Elements such as landforms, water features, and vegetation are among the building blocks of attractive and welcoming spaces, and they can also be powerful tools for enhancing security. These features can be used not only to define or designate a space, but also to deter or prevent hostile surveillance or unauthorized access. Vegetative groupings and landforms can even provide some level of blast shielding. Stands of trees, earthen berms, and similar countermeasures generally cannot replace setbacks, but they can offer supplementary protection. However, landscaping can also have detrimental impacts for safety and security, and designers should consider the unique requirements of the school project to ensure that the landscape design elements they choose will be appropriate and effective.

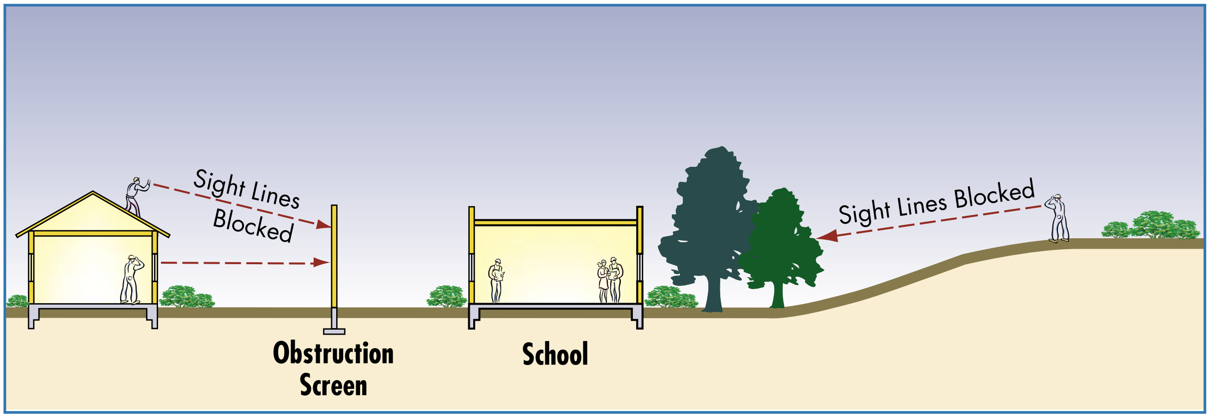
  With careful selection, placement, and maintenance, landscape elements can provide visual screening that protects school gathering areas and other activities from surveillance without creating concealment for covert activity. However, dense vegetation in close proximity to a school building can screen illicit activity and should be avoided. Additionally, thick ground cover such as English ivy or vegetation over 4 inches tall such as monkey grass can be used to conceal bombs and other weapons; in setback clear zones, vegetation should be selected and maintained with eliminating concealment opportunities in mind. Similarly, measures to screen visually detractive components such as transformers, trash compactors, and condensing units should be designed to minimize concealment opportunities for people and weapons.

- **Urban design.** Numerous urban design elements present opportunities to provide school security. The scale of the streetscape should be appropriate to its primary users, and it can be manipulated to increase the comfort level of desired users while creating a less inviting atmosphere for users with malicious intent. However, even at the pedestrian scale, certain operational requirements must be accommodated. For example, although efficient pedestrian and vehicle circulation systems are important for school functions and operations, they are also critical for emergency response, evacuation, and egress, and must be able to accommodate vehicles up to the largest fire apparatus in the community. Furthermore, despite an emphasis on downsizing the scale of the streetscape, it is critical to maintain the maximum stand-off distance possible between vehicles and structures.

  At the school perimeter, walls and fences used for space definition may be hardened to resist the impact of a weapon-laden truck; however, planters, bollards, or decorative boulders could accomplish the same objective in a much more aesthetically pleasing manner. Such an approach also creates permeability, which would allow pedestrians and cyclists to more easily move through the space.

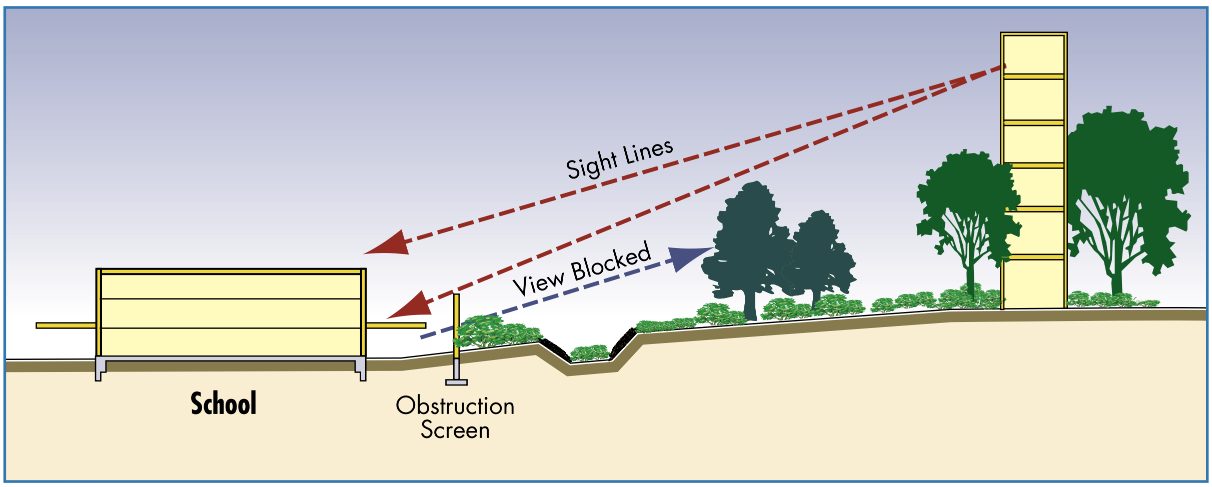
  Landscape and urban design inherently define the "lines of sight" in a space. These techniques seek to deny aggressors a "line of sight" to a potential target, either from on or off site. This increases the protection of sensitive information and operations by using stand-off weapons (see Figures 2-3 and 2-4). In addition to the use of various types of screening options, anti-surveillance measures (e.g., using building orientation, landscaping, screening, and landforms) to block sight lines can also be used.

Depending on the circumstances, landforms can be either beneficial or detrimental to anti-surveillance. Elevated sites may enhance surveillance of the surrounding area from inside the facility, but may also allow observation of on-site areas by adversaries. School buildings should not be sited immediately adjacent



SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

Figure 2-3 Blocking of sight lines



SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

Figure 2-4 Improper school siting and view relationships

to higher surrounding terrain, unsecured buildings owned by unfamiliar parties, and vegetation, drainage channels, ditches, ridges, or culverts that can provide concealment. For high-risk school buildings, it may be necessary to provide additional protection by creating a clear zone immediately adjacent to the structure that is free of all visual obstructions or landscaping (see Figure 2-5). The clear zone facilitates monitoring of the immediate vicinity and visual detection of attacks. Walkways and other circulation features within a clear zone should be located so that buildings do not block views of pedestrians and vehicles. If clear zones are implemented, it may be necessary to implement other anti-surveillance measures.

SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

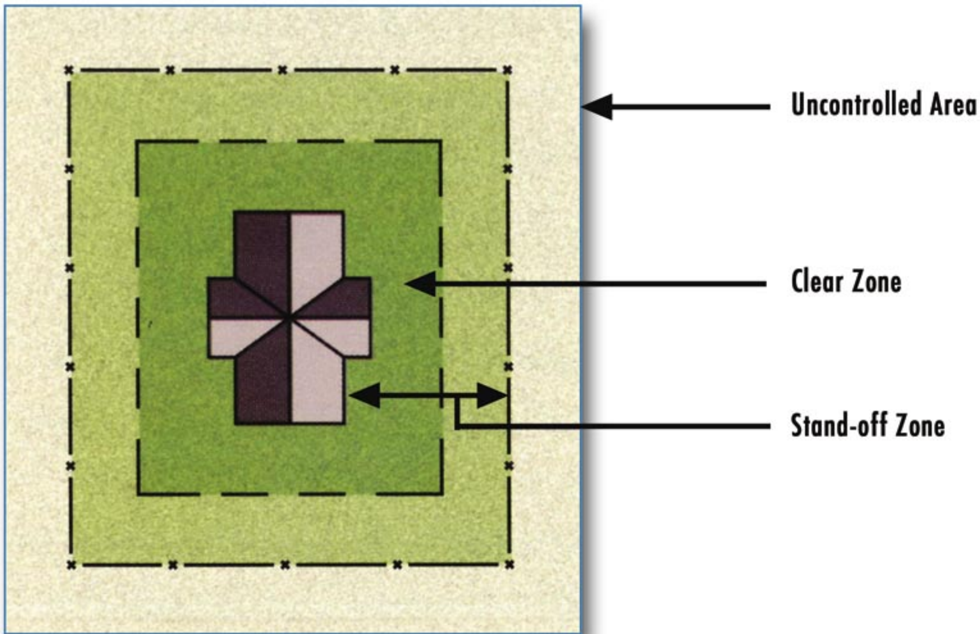
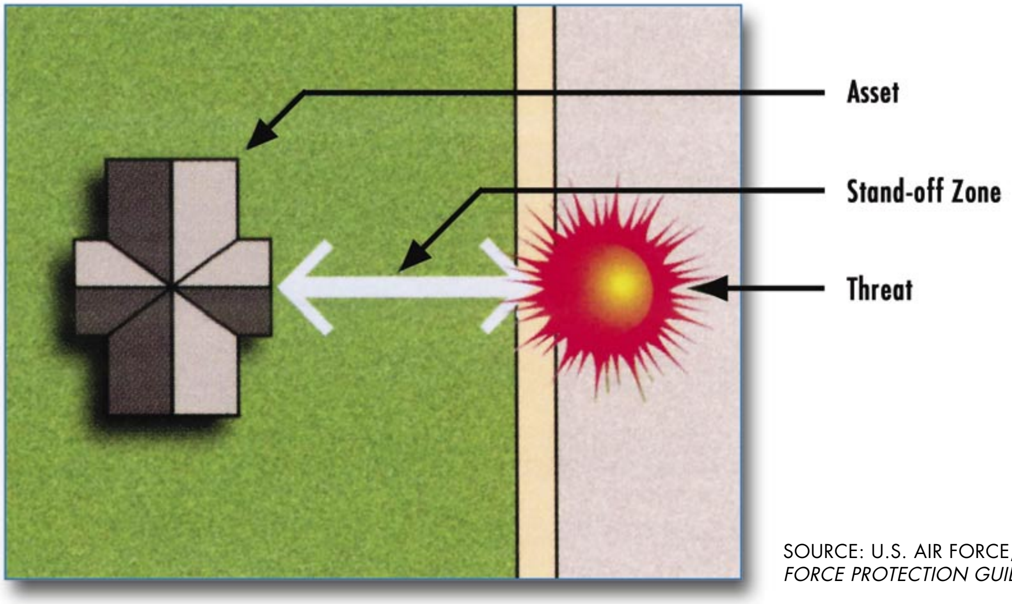


Figure 2-5 Clear zone with unobstructed views

2.3 STAND-OFF DISTANCE

The most cost-effective solution for mitigating explosive effects on school buildings is to keep explosives as far away from them as possible. The distance between an asset and a threat is referred to as the stand-off distance as shown in Figure 2-6. There is no ideal stand-off distance; it is determined by the type of threat, the type of construction, and desired level of protection. The easiest and least costly opportunity for achieving appropriate levels of protection against terrorist threats is to incorporate sufficient stand-off distance into school designs. Maximizing stand-off distance also ensures that there is opportunity in the future to upgrade school buildings to meet increased threats or to accommodate higher levels of protection. Stand-off distance must be coupled with appropriate building hardening as discussed in Chapter 3, to provide the necessary level of protection to the school.



SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

Figure 2-6 Concept of stand-off distance

For schools located in high-risk areas, additional considerations follow:

- The first mode of site protection is to create "keep out zones" that can ensure a minimum guaranteed distance between an explosion (i.e., from a vehicle) and the school structure.

- The perimeter line is the outermost line that can be protected by the security measures incorporated during the school design process. It is recommended that the perimeter line be located as far as is practical from the building exterior. Many vulnerable school buildings are located in urban areas where only the exterior wall of the building stands between the outside world and the building occupants. In this case, the options are obviously limited. Often, the perimeter line can be pushed out to the edge of the sidewalk by means of bollards, planters, and other obstacles. To push this line even further outward, restricting or eliminating parking along the curb often can be arranged with local authorities. In some extreme cases, elimination of loading zones and the closure of streets are an option.

- "Keep out zones" can be achieved with perimeter barriers that cannot be compromised by vehicular ramming. A continuous line of security should be installed along the perimeter of the site to protect it from unscreened vehicles and to keep all vehicles as far away from the school as possible.

- The following critical building components should be located away from main entrances, vehicle circulation, parking, and maintenance areas. If this is not possible, harden as appropriate:
  - Emergency generator, including fuel systems, day tank, fire sprinkler, and water supply
  - Normal fuel storage
  - Telephone distribution and main switchgear
  - Fire pumps
  - Building control centers
  - Uninterrupted power supply (UPS) systems controlling critical functions
  - Main refrigeration systems if critical to building operation
  - Elevator machinery and controls
  - Shafts for stairs, elevators, and utilities
  - Critical distribution feeders for emergency power

2.4 CONTROLLED ACCESS ZONES

For a school at high risk, one method to attain the appropriate protection is with the creation of a controlled access zone. These zones define minimum distances between a school building and potential threats through the installation of barriers (such as bollards, planters, fountains, walls, and fences). The barriers are designed to withstand assaults by terrorist vehicles; however, their placement must be designed to allow for access by fire and rescue vehicles in the event of an emergency. Selection of barriers is based on operational considerations related to vehicle access and parking. Good design principles for high-risk schools endorse the complete surround of a school building with a stand-off zone that has perimeters set at distances that consider threat levels, desired level of protection, building construction, and land availability. Entry into the controlled area should only be through an entry control point.

When designing schools at high risk, controlled access zones may be exclusive or non-exclusive, as shown in Figure 2-7. An exclusive zone is the area surrounding a school building within the exclusive control of the building. Anyone entering an exclusive zone must have a purpose related to the building. A non-exclusive zone is either a public right-of-way or a particular area related to the main school building.

SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

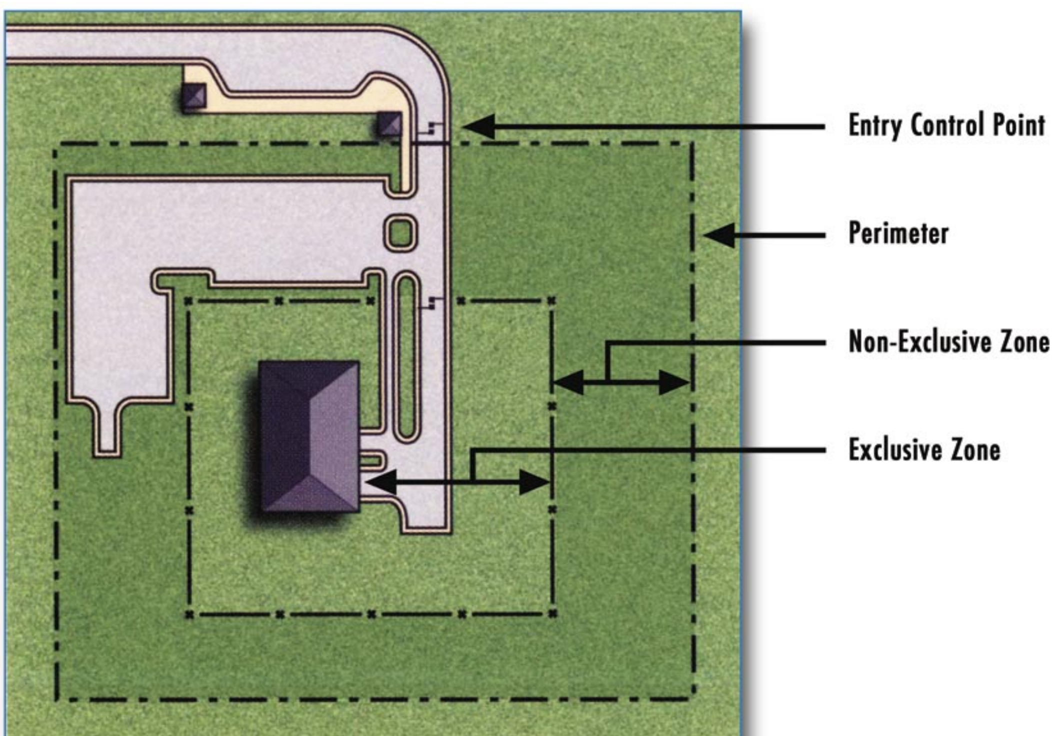


Figure 2-7 Exclusive and non-exclusive zones

The following are some security considerations applicable to controlled access zones and enforcement:

- Design and select barriers based on threat capabilities.
- If the limited availability of land precludes the creation of an exclusive zone, the use of screening surrounding the school building is an alternative.
- Design and locate security devices to establish consistent rhythm patterns within the site. Incorporate subtle and aesthetically pleasing security measures to reach the desired level of protection.
- Locate security measures so that they do not impede the free access to school public entrances or internal pedestrian flow. Miscellaneous decorative elements (e.g., flag poles, fountains, pools, gardens, and similar features) may be located within access ways to slow movement or restrict access.
- Use a combination of barriers. Some barriers are fixed and obvious (fences and gates), while others are passive (sidewalks far away from buildings, curbs with grassy areas, etc.). See Figure 2-8.

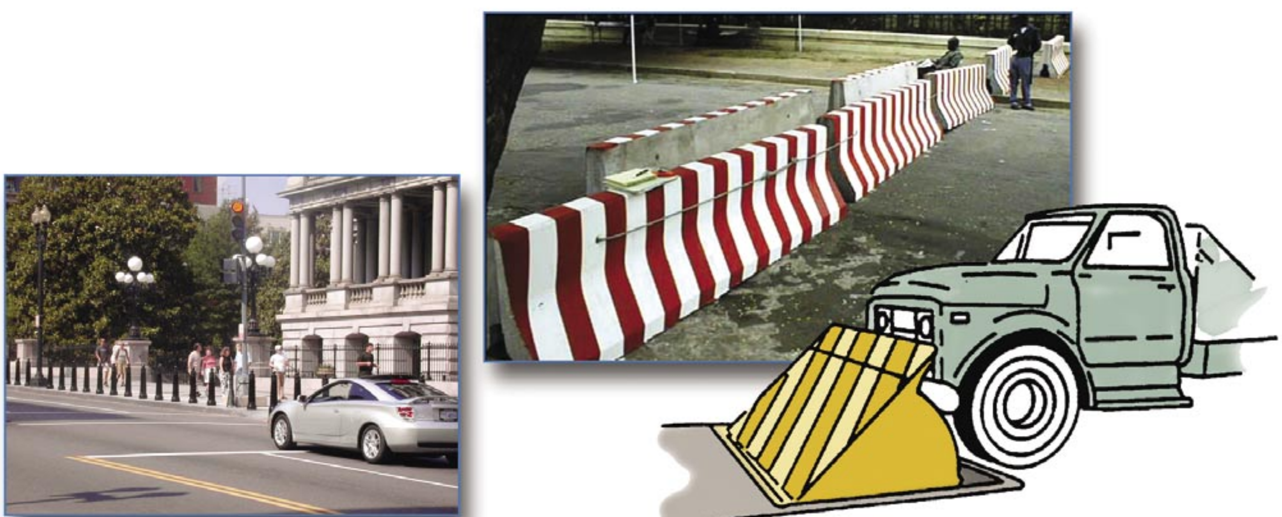


Figure 2-8 Sample bollard applications

- ❍ Consider using landscape materials to create barriers that are soft and natural rather than manmade where physical barriers are required.
- ❍ Use vehicles as temporary physical barriers by placing them in front of buildings or across access roads.
- ❍ Maintain as much stand-off distance as possible between potential vehicular bombs and the school building.
  - Provide traffic obstacles near entry control points to slow down traffic.
  - Consider vehicle barriers at building entries and drives.
  - Offset vehicle entrances from the direction of a vehicle's approach to force a reduction in speed.
  - Position gates and perimeter boundary fences outside the blast vulnerability envelope, when possible.
  - Provide a vehicle crash resistance system in the form of a low wall or earth berm, if the threat level warrants it.
- ❍ Design entry control points (if provided) to screen the building from vehicles entering it.
- ❍ Provide passive vehicle barriers to keep stationary vehicle bombs at a distance from the school building.
  - Use high curbs, low berms, shallow ditches, trees, shrubs, and other physical separations to keep stationary bombs at a distance.
  - Do not allow vehicles to park next to perimeter walls of the secured area. Consider using bollards or other devices to keep vehicles away.
- ❍ Provide adequate lighting to aid in threat detection in controlled access zones.
- ❍ Use CCTV to control entry points, the site perimeter, and exclusive and non-exclusive zones.

2.5 ENTRY CONTROL AND VEHICULAR ACCESS

In the case of a school, the objective of the design professional is to save lives by mitigating building damages and reducing the chances of a catastrophic collapse of the building at least until it is fully evacuated. Although there are many forms of attacks against a school, from the standpoint of school structural design, the vehicle bomb governs design because historically it has been used on multiple occasions by terrorists. Where a school perimeter barrier is required for security, it will be necessary to provide points of access through the perimeter for school users (i.e., students, faculty, staff, visitors, and service providers). An entry control point or guard building serves as the designated point of entry for site access. It provides a point for implementation of desired/required levels of screening and access control. The objective of the entry control point is to prevent unauthorized access to school grounds while maximizing the rate of authorized access by foot or vehicle. These measures will not be required for all schools; they may only be appropriate for schools considered at high risk. Designs should be flexible to allow implementation of increased security controls when schools are placed in high alert and easing of controls at lower threat levels. For a school considered to be at high risk, the following should be considered in the design of entry control points:

- Design entry roads to schools so that they do not provide direct or straight-line vehicular access to the main building. Route major corridors away from key school areas and functions.
- Design access points at an angle to oncoming streets so that is difficult for a vehicle to gain enough speed to break through them.
- Minimize the number of access roads and entrances into a school.
- Provide a drop-off/pick-up lane for buses only.

- ❍ Minimize the number of driveways or parking lots that students will have to walk across to get to the school building.
- ❍ Designate an entry to the school for commercial, service, and delivery vehicles, preferably away from key school areas and functions, whenever possible.
- ❍ Design the entry control point and guard building so that the authorization of approaching vehicles and occupants can be adequately assessed, and the safety of both gate guards and approaching vehicles can be maintained when a school is placed at high alert).
- ❍ Design (if they are required) traffic calming strategies and barriers (road alignment, retractable bollards, swing gates, or speed bumps) to control vehicle speed and slow incoming vehicles before they reach the gate so that entry control personnel have adequate time to respond to unauthorized activities.
- ❍ Provide inspection areas that are not visible to the public. Place appropriate landscape plantings to accomplish screening.
- ❍ Provide pull-over lanes at site entry gates to check suspect vehicles. Also, provide a visitor/site personnel inspection area to inspect vehicles prior to allowing access to the school site.
- ❍ Consider providing a walkway and turnstile for pedestrians and a dedicated bicycle lane.

2.6 SIGNAGE

Signs are an important element of school security. They are meant to keep intruders out of restricted areas. Confusion over site circulation, parking, and entrance locations can contribute to a loss of site security. Signs should be provided off site and at school entrances; there should be on-site directional, parking, and cautionary signs for students, faculty, staff, visitors, service vehicles, and pedestrians. Unless required, signs should not identify sensitive areas. A comprehensive signage plan should include the following:

- Prepare entry control procedures signs that explain current entry procedures for drivers and pedestrians.
- Prepare traffic regulatory and directional signs that control traffic flow and direct vehicles to specific appropriate points.
- Consider using street addresses or building numbers instead of detailed descriptive information inside the school grounds.
- Minimize the number of signs identifying high-risk areas; however, a significant number of warning signs should be erected to ensure that possible intruders are aware of entry into restricted areas.
- Minimize signs identifying critical utility complexes (e.g., power stations and significant gas, water, and sewer). Post easily understandable signs to minimize accidental entry by unauthorized visitors into critical areas.
- In areas where English is one of two or more languages commonly spoken, warning signs must contain the other language(s) in addition to English. The signs should be posted at intervals of no more than 100 feet and should not be mounted on fences equipped with intrusion-detection equipment.
- Locate variable message signs, which give information on site/organization special events and visitors, far inside site perimeters.

2.7 PARKING

Parking restrictions can help to keep potential threats away from a school building. In urban settings, however, curbside or underground parking is often necessary and sometimes difficult to control. Mitigating the risks associated with parking requires creative design measures, including parking restrictions, perimeter buffer zones, barriers, structural hardening, and other architectural and engineering solutions. The following considerations may help designers to implement parking measures for schools that may be at high risk:

- Locate vehicle parking areas away from school buildings to minimize blast effects from potential vehicle bombs.
- Provide separate parking areas for students, faculty, staff, and visitors who may be going in and out during the school day. (This allows the main student parking lot to be closed off during the school day.)
- If possible, locate visitor or general public parking near, but not on, the site itself.
- Locate general parking in areas that provide the fewest security risks to school personnel.
- Consider one-way circulation within a school parking lot to facilitate monitoring for potential aggressors.
- Locate parking within view of occupied school buildings while maintaining stand-off.
- Prohibit parking within the stand-off zone.
- Request appropriate permits to restrict parking in the curb lane for school vehicles or key employee parking only where distance from the building to the nearest curb provides insufficient setback, and compensating design measures do not sufficiently protect the building from the assessed threat. If necessary, use structural features to prevent parking.
- Provide appropriate setback from parking on adjacent properties, if possible. Structural hardening may be required if the setback is insufficient. In new designs, it may be possible to adjust the location of the school building on the site to provide adequate setback from adjacent properties.
- When establishing parking areas, provide emergency communications systems (e.g., intercom, telephones, etc.) at readily identified, well-lighted, CCTV monitored locations to permit direct contact with security personnel.

- ❍ Provide parking lots with CCTV cameras connected to the security system and adequate lighting capable of displaying and videotaping lot activity.
- ❍ If possible, prohibit parking beneath or within a school building.
- ❍ If parking beneath a building is unavoidable, limit access to the parking areas and ensure they are secure, well-lighted, and free of places of concealment.
- ❍ Apply the following restrictions If parking within a school building is required:
  - Public parking with identification (ID) check
  - School vehicles and school employees and students only
  - Selected school employees only, or those requiring security

2.8 LOADING DOCKS AND SERVICE ACCESS

Loading docks and service access areas are commonly required for a school building and are typically desired to be kept as invisible as possible. For this reason, special attention should be devoted to these service areas in order to avoid intruders. Design criteria for school loading docks and service access include the following:

- ❍ Separate by at least 50 feet, loading docks and shipping and receiving areas in any direction from utility rooms, utility mains, and service entrances, including electrical, telephone/data, fire detection/alarm systems, fire suppression water mains, cooling and heating mains, etc.
- ❍ Locate loading docks so that vehicles will not be allowed under the building. If this is not possible, the service area should be hardened for blast. Loading dock design should limit damage to adjacent areas and vent explosive forces to the exterior of the building.
- ❍ If loading zones or drive-through areas are necessary, monitor them and restrict height to keep out large vehicles.

- Avoid having driveways within or under school buildings.
- Provide adequate design to prevent extreme damage to loading docks. The floor of the loading dock does not need to be designed for blast resistance if the area below is not occupied and or does not contain critical utilities. In certain cases, significant structural damage to the walls and ceiling of the loading dock may be acceptable; however, the areas adjacent to the loading dock should not experience severe structural damage or collapse.
- Provide signage to clearly mark separate entrances for deliveries.

2.9 PHYSICAL SECURITY LIGHTING

Security lighting can be provided for overall school ground/ building illumination and the perimeter to allow security personnel to maintain visual-assessment during darkness. It may provide both a real and psychological deterrent for continuous or periodic observation. Lighting is relatively inexpensive to maintain and may reduce the need for security personnel while enhancing personal protection by reducing opportunities for concealment and surprise by potential attackers.

Provide sufficient lighting at entry control points to ensure adequate lighting for the area. Where practical, place lighting elements as high as possible to give a broader, more natural light distribution. This requires fewer poles (less hazardous to drivers) and is more aesthetically pleasing than standard lighting.

The type of site lighting system used depends on the school's overall security requirements. Four types of lighting are used for security lighting systems:

- **Continuous lighting** is the most common security lighting system. It consists of a series of fixed lights arranged to flood a given area continuously during darkness with overlapping cones of light.

- **Standby lighting** has a layout similar to continuous lighting; however, the lights are not continuously lit, but are either automatically or manually turned on when suspicious activity is detected or suspected by the security personnel or alarm systems.
- **Movable lighting** consists of manually operated, movable searchlights that may be lit during hours of darkness or only as needed. The system normally is used to supplement continuous or standby lighting.
- **Emergency lighting** is a backup power system of lighting that may duplicate any or all of the above systems. Its use is limited to times of power failure or other emergencies that render the normal system inoperative. It depends on an alternative power source such as installed or portable generators or batteries. Consider emergency/backup power for security lighting as determined to be appropriate.

2.10 SITE UTILITIES

Utility systems can suffer significant damage when subjected to the shock of an explosion. Some of these utilities may be critical for safely evacuating people from the school building. Their destruction could cause damage that is disproportionate to other building damage resulting from an explosion. To minimize the possibility of such hazards, apply the following measures:

- Where possible, provide underground, concealed, and protected utilities.
- Provide redundant utility systems (particularly electrical services) to support school security, life safety, and rescue functions.
- Consider quick connects for portable utility backup systems if redundant sources are not available.
- Prepare vulnerability assessments for all utility services to the school, including all utility lines, storm sewers, gas transmission lines, electricity transmission lines, and other utilities that may cross the site perimeter.

- ❍ Protect drinking water supplies from waterborne contaminants by securing access points, such as manholes. If warranted, maintain routine water testing to help detect waterborne contaminants.
- ❍ Minimize signs identifying critical utilities. Provide fencing to prevent unauthorized access and use landscape planting to conceal aboveground systems.
- ❍ Locate petroleum, oil, and lubricants storage tanks and operations buildings downslope from all other occupied school buildings. Locate fuel storage tanks at least 100 feet from buildings.
- ❍ Consider providing utility systems with redundant or loop service, particularly in the case of electrical systems. Where more than one source or service is not currently available, provisions should be made for future connections. In the interim, consider "quick connects" at the building for portable backup systems.
- ❍ Decentralize a school's communications resources, when possible; the use of multiple communication networks will strengthen the communications system's ability to withstand the effects of a terrorist attack.
- ❍ Place trash receptacles as far away from the building as possible; trash receptacles should not be placed within 30 feet of a building.
- ❍ Provide a school-wide public address system that extends from the interior to the exterior of buildings.
- ❍ Conceal and harden incoming utility systems within schools to provide blast protection, including burial or proper encasement wherever possible.
- ❍ Locate utility systems at least 50 feet from loading docks, front entrances, and parking areas.
- ❍ Route critical or fragile utilities so that they are not on exterior walls or on walls shared with mailrooms.

- Ensure that the redundant utilities are not collocated or do not run in the same chases. This minimizes the possibility that both sets of utilities will be adversely affected by a single event.
- Ensure backup systems are located away from the systems components for which they provide backup.
- Mount all overhead utilities and other fixtures weighing 31 pounds (14 kilograms) or more to minimize the likelihood that they will fall and injure school occupants. Design all equipment mountings to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction. This standard does not preclude the need to design equipment mountings for forces required by other criteria such as seismic standards.
- Ensure that access to crawl spaces, utility tunnels, and other means of under school building access is controlled to limit opportunities for aggressors placing explosives underneath buildings.
- Screen, seal, or secure all utility penetrations of the site's perimeter to prevent their use as access points for unauthorized entry into the school site. If access is required for maintenance of utilities, secure all penetrations with screening, grating, latticework, or other similar devices.

2.11 SUMMARY OF SITE MITIGATION MEASURES

A general spectrum of site mitigation measures ranging from the least protection, cost, and effort going to the greatest protection, cost, and effort for a school site is presented below. Detailed discussions of individual measures can be found earlier in the chapter. This is a nominal ranking of mitigation measures. In practice, the effectiveness and cost of individual mitigation measures may be different for specific applications. Table 2-1 can be used by designers and school administrators to correlate the mitigation measures described in this chapter to specific terrorist threats and tactics.

- Place trash receptacles as far away from the school building as possible.
- Remove any dense vegetation that may screen covert activity.
- Use thorn-bearing plant materials to create natural barriers.
- Identify all critical resources in the school area (fire and police stations, hospitals, etc.) for design consideration.
- Identify all potentially hazardous facilities in the area (nuclear plants, chemical labs, etc.).
- Use temporary passive barriers to eliminate straight-line vehicular access to areas of limited access.
- Use vehicles as temporary physical barriers during elevated threat conditions.
- Make proper use of signs for traffic control, building entry control, etc. Minimize signs identifying high-risk areas.
- Identify, secure, and control access to all utility services to the school.
- Limit and control access to all school crawl spaces, utility tunnels, and other means of under building access to prevent the planting of explosives.
- Utilize GIS to assess adjacent land use.
- Provide open space inside the fence along the school perimeter.
- Locate fuel storage tanks at least 100 feet from all occupied school buildings.
- Block sight lines through building orientation, landscaping, screening, and landforms.
- Use temporary and procedural measures to restrict parking and increase stand-off.
- Locate and consolidate high-risk land uses in the interior of the school site.
- Select and design barriers based on threat levels.
- Maintain as much stand-off distance as possible from potential vehicle bombs.
- Separate backup utility systems.
- Conduct periodic water testing to detect waterborne contaminants.
- Enclose the perimeter of the school. Create a single controlled entrance for vehicles (entry control point).
- Establish law enforcement or security force presence for schools facing high threats.
- Install quick connects for portable utility backup systems.
- Install security lighting in areas where needed.
- Install CCTV cameras in areas where needed.
- Mount all equipment to resist forces in any direction.
- Include security and protection measures in the calculation of school land area requirements.
- Redesign and construct parking to provide adequate stand-off for vehicle bombs.
- Position buildings to permit occupants and security personnel to monitor the site.
- Do not site the school building adjacent to potential threats or hazards.
- Locate critical school building components away from the main entrance, vehicle circulation, parking, or maintenance area. Harden as appropriate.
- Provide a site-wide public address system and emergency call boxes at readily identified locations.
- Prohibit parking beneath or within a school building.
- Redesign and construct access points at an angle to oncoming streets.
- Designate entry points for commercial and delivery vehicles away from high-risk areas.
- In urban areas, push the perimeter out to the edge of the sidewalk by means of bollards, planters, and other obstacles. For even better stand-off, push the line even farther outward by restricting or eliminating parking along the curb, eliminating loading zones, or through street closings.
- Provide intrusion detection sensors for all utility services to the school.
- Provide backup utility systems to support school security, life safety, and rescue functions.
- Conceal and/or harden incoming utility systems.
- Install active vehicle crash barriers.

Table 2-1 Correlation of Mitigation Measures to Threats*

■ The symbols indicate which of the protective measures shown in the left-hand column can be effective in countering the types of threats indicated across the top of the chart.

	Moving Vehicle Bomb	Stationary Vehicle Bomb	Exterior Attack	Stand-off Weapons Attack	Armed Attack	Covert Entry	Mail and Supplies Bombs	Airborne Contamination	Waterborne Contamination
LAND USE CONSIDERATIONS									
Locate high-risk land uses in the interior of the school site	■	■	■	■	■				
Consolidate high-risk land uses	■	■	■	■	■				
Include stand-off areas in land area requirements	■	■		■	■				
Consider effects of development off-property development	■	■	■		■				
SITE PLANNING									
Maximize distance from perimeter fence and developed areas	■	■	■	■	■			■	
Site critical school facilities on higher ground	■	■	■	■	■			■	■
Avoid areas with adjacent high terrain or structures			■	■	■			■	■
Avoid areas with adjacent dense vegetation			■	■	■				
Avoiding low-lying topographic areas			■	■	■			■	■
Site school facilities within view of other occupied facilities						■			
Create complexes to enhance surveillance opportunities	■	■	■	■	■				
Eliminate vehicle parking from interior of building complexes	■	■							
High surrounding terrain			■	■	■				
Distance from non-school facilities	■	■	■	■	■	■		■	■
Areas that provide concealment		■	■	■	■	■			
Earth berms		■	■	■	■				
Bodies of water	■	■	■	■	■	■			
Depressions			■	■	■				
Vehicle access	■	■							
Dense thorn-bearing vegetation			■			■			
Vegetation screens		■	■	■	■	■			
Location of trash receptacles							■		

Table 2-1: Correlation of Mitigation Measures to Threats* (continued)

	Moving Vehicle Bomb	Stationary Vehicle Bomb	Exterior Attack	Stand-off Weapons Attack	Armed Attack	Covert Entry	Mail and Supplies Bombs	Airborne Contamination	Waterborne Contamination
STAND-OFF DISTANCE									
Stand-off zone	■	■		■	■	■			
CONTROLLED ACCESS ZONES									
Exclusive zone/Non-exclusive zone	■	■				■			
Clear zone	■	■				■			
Fencing and physical barriers	■	■	■	■	■	■			
Active barriers	■	■	■	■	■	■			
Passive barriers	■	■	■			■			
ENTRY CONTROL AND VEHICULAR ACCESS									
Minimize access roads	■	■				■	■		
Control points	■	■	■	■	■	■			
Active monitoring	■	■	■	■	■	■	■	■	■
Provide enhanced protection at school entrances	■	■	■	■	■	■			
Include pull-over lanes at checkpoints to inspect vehicles	■	■	■	■	■	■			
Avoid straight-line vehicular access to high-risk areas	■	■							
Avoid straight-line entry approach roads	■	■							
Locate vehicle parking areas far from high-risk areas	■	■							
Provide separate service and delivery access	■	■							
Route major corridors away from high-risk areas	■	■		■	■				
Locate high-risk resources remote from primary roads	■	■		■	■				
Minimize directional identification signs	■	■	■	■	■	■			
Limit vehicular access to high-risk areas	■	■	■	■	■	■			
SIGNAGE									
Minimize signage	■	■	■	■	■	■	■	■	■

Table 2-1: Correlation of Mitigation Measures to Threats* (continued)

	Moving Vehicle Bomb	Stationary Vehicle Bomb	Exterior Attack	Stand-off Weapons Attack	Armed Attack	Covert Entry	Mail and Supplies Bombs	Airborne Contamination	Waterborne Contamination
PARKING									
View of parking		■							
Parking under a building		■							
Parking at interior of facility		■							
Parking near high-risk areas		■							
Parking in exclusive zone		■							
One-way circulation	■	■	■			■			
LOADING DOCKS AND SERVICE ACCESS									
Loading/unloading docks		■					■		
Driveways under facilities	■	■							
PHYSICAL SECURITY LIGHTING									
Lighting		■	■			■			
SITE UTILITIES									
Provide protection at culverts, sewers, and pipelines					■	■			■
Provide protection at concrete trenches, storm drains, and duct systems					■	■			■
Provide and check locks on manhole covers					■	■			■
Minimize signs identifying utility systems					■	■			■
Provide fencing at critical utility complexes						■			■
Use landscape planting to conceal aboveground systems						■			■
Install utilities underground	■	■	■	■	■	■	■		
Locate fuel/lube storage downslope and away from facilities	■	■	■	■	■	■	■		
Provide redundant utility systems and loop service	■	■	■	■	■	■	■		
Provide utility "quick disconnects" for portable backup systems	■	■	■	■	■	■	■		

Table 2-1: Correlation of Mitigation Measures to Threats* (continued)

	Moving Vehicle Bomb	Stationary Vehicle Bomb	Exterior Attack	Stand-off Weapons Attack	Armed Attack	Covert Entry	Mail and Supplies Bombs	Airborne Contamination	Waterborne Contamination
Decentralize communications resources	■	■	■	■	■	■	■		
Use multiple communications networks	■	■	■	■	■	■	■		
Conceal and protect network control centers	■	■	■	■	■	■	■		
Public address system			■		■			■	■
Underground utilities	■	■	■	■					■
Redundant utilities	■	■	■	■	■				■
Quick disconnects	■	■	■	■	■				
Remote fuel storage	■	■	■	■	■				

* ADAPTED FROM U.S. AIR FORCE *INSTALLATION FORCE PROTECTION GUIDE*.

2.12 CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN (CPTED)

CPTED is a crime reduction technique that has several key elements applicable to the analysis of building function and site design against physical attack. It is used by architects, city planners, landscape and interior designers, and law enforcement with the objective of creating a climate of safety in a community by designing a physical environment that positively influences human behavior. Although CPTED principles are not incorporated into the assessment process presented in this primer, it is useful to briefly discuss CPTED because it is often entwined with terrorism protection measures.

CPTED concepts have been successfully applied in a wide variety of applications, including streets, parks, museums, government buildings, houses, and commercial complexes. The approach is particularly applicable to schools, where outdated facilities are common. Most schools in the United States were built 30 to 60 or more years ago. Security issues were almost nonexistent at the time, and technology was dramatically different. As a result, building designs are not always compatible with today's more security-conscious environment.

According to CPTED principles, depending upon purely conventional physical security measures (e.g., security guards and metal detectors) to correct objectionable student behavior may have its limitations. Although employing physical security measures will no doubt increase the level of physical security, in some cases physical security measures employed as stand-alone measures may lead to a more negative environment, thereby enhancing violence. In short, employing stand-alone physical security measures may fail to address the underlying behavioral patterns that adversely affect the school environment. CPTED analysis focuses on creating changes to the physical and social environment that will reinforce positive behavior.

CPTED builds on three strategies:

- Territoriality (using buildings, fences, pavement, sign, and landscaping to express ownership)
- Natural surveillance (placing physical features, activities, and people to maximize visibility)
- Access control (the judicial placement of entrances, exits, fencing, landscaping, and lighting)

A CPTED analysis of a school evaluates crime rates, office-referral data, and school cohesiveness and stability, as well as core design shortcomings of the physical environment (e.g., blind hallways, uncontrolled entries, or abandoned areas that attract problem behavior). The application of CPTED principles starts with a threat and vulnerability analysis to determine the potential for attack and what needs to be protected. Protecting a school from physical attack by criminal behavior or terrorist activity, in many cases, only reflects a change in the level and types of threats. The CPTED process asks questions about territoriality, natural surveillance, and access control that can:

- Increase the effort to commit crime or terrorism
- Increase the risks associated with crime or terrorism
- Reduce the rewards associated with crime or terrorism
- Remove the excuses as to why people do not comply with the rules and behave inappropriately

The CPTED process provides direction to solve the challenges of crime and terrorism with organizational (people), mechanical (technology and hardware), and natural design (architecture and circulation flow) methods.

CPTED concepts can be integrated into expansion or reconstruction plans for existing buildings as well as new buildings. Applying CPTED concepts from the beginning usually has minimal impact on costs, and the result is a safer school. Each school, district, and community should institute measures appropriate for their own circumstances because there is no a single solution that will fit all schools.

Many CPTED crime prevention techniques for a school complement conventional terrorism and physical attack prevention measures. For example, as part of the CPTED strategy of improving territoriality, schools are encouraged to direct all visitors through one entrance that offers contact with a receptionist who can determine the purpose of the visit and the destination, and provide sign-in/sign-out and an ID tag prior to building access. These CPTED measures are similar to and complement physical security entry control point stations.

However, in some cases, CPTED techniques can conflict with basic physical security principles. The CPTED strategy of natural surveillance calls for locating student parking in areas that allow ease of monitoring. A design that locates student parking close to the principal's office also reduces vehicle stand-off and could create a vulnerability of the school structure to a vehicle bomb. In cases where CPTED techniques conflict with security principles, designers and school administrators should seek innovative solutions tailored to their unique situation.

BUILDING DESIGN GUIDANCE AND SAFETY PLANS 3

This chapter addresses explosive blast and CBR concerns from terrorist attacks, highlighting mitigation measures, including architectural, structural, and building envelope systems, and school safety plans. After the site design considerations to enhance protection presented in Chapter 2 have been taken into account, additional building design measures, such as hardening and CBR mitigation measures, must be considered to protect school occupants. Historically, the majority of fatalities that occur in terrorist attacks directed against buildings are due to building collapse. This was true for the Oklahoma City bombing in 1995 when 87 percent of the building occupants who were killed were in the collapsed portion of the Murrah Federal Building.

When considering mitigation measures for explosive blast threats, the primary strategy is to keep explosive devices as far away from the school building as possible (maximize stand-off distance). This is usually the easiest and least costly way to achieve a desired level of protection. In cases where sufficient stand-off distance is not available to protect against progressive collapse of a school building (i.e., schools located in urban settings), hardening of the building's structural systems may be required. Designers should try to minimize hazardous flying debris during an explosive event because a high number of injuries can result from flying glass fragments and debris from walls, ceilings, and non-structural features. Another consideration is to balance the hardening of the building envelope so that the columns, walls, windows, and glazing have approximately equal response for damage and injury/casualty for the design basis threat weapon at the available stand-off distance. Window design is the element that is usually the most diverse in conventional construction. Good blast engineering is a multi-disciplinary effort that requires the concerted efforts of the architect, structural engineer, mechanical engineer, and the other design team members in order to achieve a balanced building envelope.

When considering mitigation measures for CBR hazards, heating, ventilation, and air conditioning (HVAC) systems are of particular concern. A school building can provide protection against CBR agents released outdoors if the flow of fresh air is filtered or interrupted; however, HVAC systems can also become an entry point and distribution system for hazardous contaminants. If installed, HVAC air filtration and air-cleaning systems can reduce the effects of a CBR agent by removing the contaminants from the air within a building. There are a variety of ways to protect school building occupants from airborne hazards. These protective measures can be as simple as defining a protective action plan or as complex as strict design measures practical only for new construction. Specific HVAC design measures will be discussed in this chapter. In addition, Chapter 5 contains a discussion of CBR protective actions.

School building design should be optimized to facilitate emergency evacuation, rescue, and recovery efforts through effective placement, structural design, and redundancy of emergency exits and critical mechanical/electrical systems. Through effective structural design, the overall damage levels may be reduced to make it easier for people to get out safely and allow emergency responders to enter safely. The designer must also balance measures to protect people with the requirements of the Americans with Disabilities Act Accessibility Guidelines (ADAAG), Uniform Federal Accessibility Standards (UFAS), National Fire Protection Codes (NFPC), and all applicable local building codes. Additional information is available in FEMA 426, *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings,* and FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks.*

3.1 ARCHITECTURAL

Several architectural considerations can be implemented to mitigate the effects of a terrorist bombing on a school facility. These considerations often cost nothing or very little if implemented early in the design process.

The shape of the school building can contribute to the overall damage to the structure. For example, "U" or "L" shaped buildings tend to trap shock waves, which may exacerbate the effect of explosive blasts. For this reason, it is recommended that re-entrant corners be avoided (see Figure 3-1). In general, convex rather than concave shapes are preferred when designing the exterior of a school building. Other considerations follow:

- Orient school buildings horizontally rather than vertically to reduce the building's profile and exposure.
- Elevate the ground floors of school buildings above grade to prevent vehicles from being driven into the facility.
- Avoid eaves and overhangs, because they can be points of high local pressure and suction during blasts. When these elements are used, they should be designed to withstand blast effects.
- Locate utility systems away from likely areas of potential attack, such as loading docks, lobbies, and parking areas.
- Orient glazing perpendicular to the primary facade to reduce exposure to blast and projectiles (see Figure 3-2).
- Avoid having exposed structural elements (e.g., columns) on the exterior of the school.

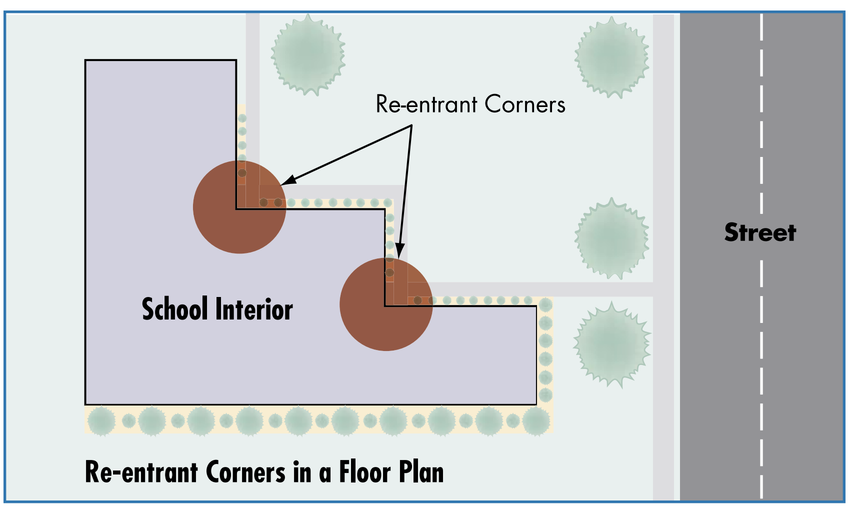


Figure 3-1 Re-entrant corners in a floor plan

SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

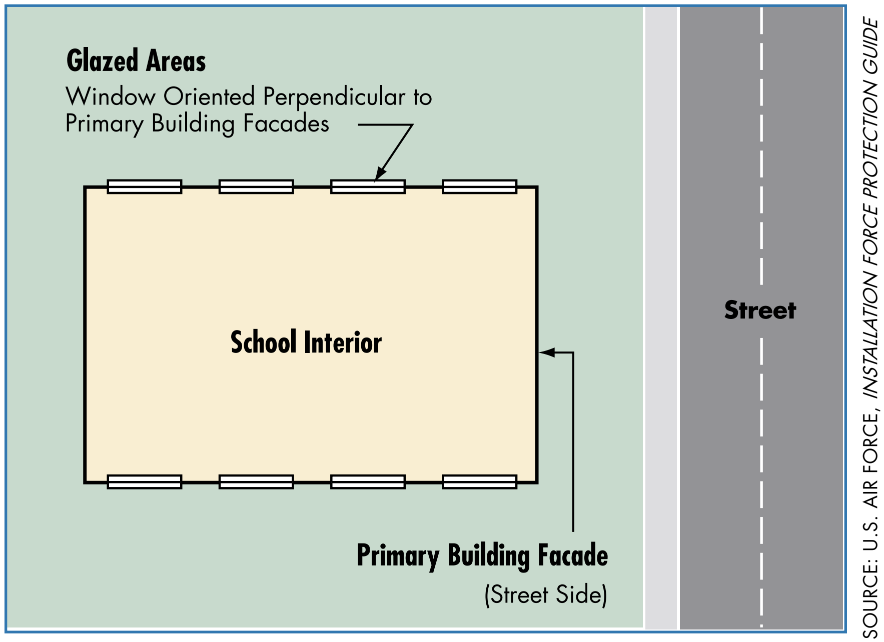
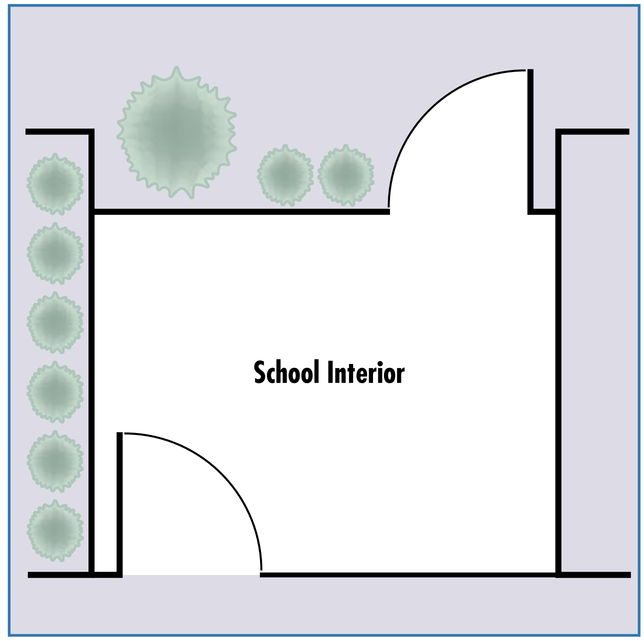


Figure 3-2 Glazed areas oriented perpendicularly away from streets

- ❍ Connect interior non-load bearing walls to the structure with flexible connections.
- ❍ Place areas of high visitor activity away from key assets.
- ❍ Eliminate hiding places within the school building.
- ❍ Locate assets in areas where they are visible to more than one person.
- ❍ Use interior barriers to differentiate levels of security within a school building.
- ❍ Stagger doors located across from one another in interior hallways to limit the effects of a blast through the school structure (see Figure 3-3).
- ❍ Provide foyers with reinforced concrete walls, and offset interior and exterior doors from each other in the foyer.
- ❍ Locate stairwells required for emergency as remotely as possible from areas where blast events might occur.

- Wherever possible, do not discharge stairs into lobbies, parking, or loading areas.
- Separate unsecured areas of the main school building as much as possible. For example, a separate lobby pavilion or loading dock area outside of the main footprint of the building provides enhanced protection against damages and potential building collapse in the event of an explosion. This can also be done by creating internal "hard lines" or buffer zones, using secondary stairwells, elevator shafts, corridors, and storage areas between public and secured areas.



SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

Figure 3-3 Offset doors through the foyer

- Place parking areas outside the main footprint of the school building to reduce the vulnerability to catastrophic collapse.

3.2 BUILDING STRUCTURAL AND NON-STRUCTURAL SYSTEMS

For schools that require high security measures, explosive blast threats may govern building design. A structural engineer should determine the school design features needed to achieve the desired level of protection against the design blast threat, considering both the collapse of the school building as well as incipient injuries and fatalities of students, faculty, and staff.

Progressive collapse is a situation where local failure of a primary structural component leads to the collapse of adjoining members which, in turn, leads to additional collapse. Hence the total damage is disproportionate to the original cause. Progressive collapse is a chain reaction of structural failures that follows from damage to a relatively small portion of a structure.

All new school buildings should be designed with the intent of reducing the potential for progressive collapse as a result of an abnormal loading event, regardless of the required level of protection. The following structural characteristics (from GSA *Progressive Collapse Analysis and Design Guidelines for New Federal Office Buildings and Major Modernization* Projects, November 2000) should be considered in the initial phases of structural design. Incorporation of these features will provide a much more robust structure and decrease the potential for progressive collapse.

- **Redundancy.** The use of redundant lateral and vertical force resisting systems is highly encouraged when considering progressive collapse. Redundancy tends to promote a more robust structure and helps to ensure that alternate load paths are available in the case of a structural element(s) failure. Additionally, redundancy provides multiple locations for yielding to occur, which increases the probability that damage will be constrained.

- **The use of ductile (flexible) structural elements and detailing.** It is critical that both the primary and secondary structural elements be capable of deforming well beyond the elastic limit without experiencing structural collapse. Hence, the use of ductile construction materials (i.e., steel, cast-in-place reinforced concrete, etc.) for both the structural elements and connection detailing is encouraged. The capability of achieving a ductile response is imperative when considering an extreme redistribution of loading such as that encountered in a structural element(s) failure.

- **Capacity for resisting load reversals.** Both the primary and secondary structural elements should be designed to resist load reversals in the case of a structural element(s) failure.

- **Capacity for resisting shear failure.** Primary structural elements maintain sufficient strength and ductility under an abnormal loading event to preclude a shear failure. If the shear capacity is reached before flexural capacity, a sudden, non-ductile failure of the element could potentially lead to a progressive collapse of the structure.

Both the GSA and DoD take a threat-independent approach to progressive collapse. The goal of a threat-independent approach is not to prevent collapse from a specific design threat, but to control and stop the continuing spread of damage after localized damage or localized collapse has occurred.

The GSA and DoD require that the structural response of a building be analyzed in a test that removes a key structural element (e.g., vertical load carrying column, section of bearing wall, beam, etc.) to simulate local damage from an explosion. If effective alternative load paths are available for redistributing the loads, originally supported by the removed structural element, the building has a low potential for progressive collapse.

For higher levels of protection from blast, cast-in-place reinforced concrete is normally the construction type of choice. Other types of construction such as properly designed and detailed steel structures are also allowed. Several material and construction types, although not disallowed by these criteria, may be undesirable and uneconomical for protection from blast.

The following guidelines are commonly used to mitigate the effects of blast on structures and to mitigate the potential for progressive collapse. See sidebar for details and more guidance.

- ❍ Use multiple barrier materials and construction techniques to mitigate the effects of blast on a structure at less expense than a single material or technique.

The following additional references are recommended:

- Biggs, John M. Introduction to Structural Dynamics. McGraw-Hill. (1964).
- The Institute of Structural Engineers. The Structural Engineer's Response to Explosive Damage. SETO, Ltd., 11 Upper Belgrave Street, London SW1X8BH. (1995).
- Mays, G.S. and Smith, P.D. Blast Effects on Buildings: Design of Buildings to Optimize Resistance to Blast Loading. Thomas Telford Publications, 1 Heron Quay, London E14 4JD. (1995).
- National Research Council. Protecting Buildings from Bomb Damage. National Academy Press. (1995).

- Incorporate internal damping into the structural system to absorb blast impact.
- Use symmetric reinforcement to increase the ultimate load capacity of the structure.
- Incorporate design redundancy and alternative load paths to help mitigate blasts and reduce the chance of progressive collapse. The Murrah Federal Building's structural system did not have any redundancy for the slab and beam systems.
- Strengthen the structural system to help resist the effects of a blast.
- Incorporate inelastic or post elastic design to allow the structure to absorb the energy of the explosion through plastic deformation.
- Recognize that components might act in directions for which they were not designed. This is due to the engulfment of structural members by blast, the negative phase, the upward loading of elements, and dynamic rebound of members. Making steel reinforcement (positive and negative faces) symmetric in all floor slabs, roof slabs, walls, beams, and girders will address this issue. Symmetric reinforcement also increases the ultimate load capacity of the members.
- Ensure that lap splices fully develop the capacity of the reinforcement.
- Stagger lap splices and other discontinuities.
- Control deflections around certain members, such as windows, to prevent premature failure. Additional reinforcement is generally required.
- Use wire mesh in plaster to reduce the incidence of flying fragments.
- Avoid the use of masonry when blast is a threat. Masonry walls break up readily and become secondary fragments during blasts.

- ❍ Use ductile connections for steel construction and develop as much moment connection as practical. Connections for cladding and exterior walls to steel frames should develop the capacity of the wall system under blast loads.
- ❍ Avoid single-point failures that can cascade, producing widespread catastrophic collapse. A prime example is the use of transfer beams and girders that, if lost, may cause progressive collapse and are, therefore, highly discouraged.
- ❍ Incorporate redundancy and alternative load paths into design to mitigate blast loads. One method of accomplishing this is to use two-way reinforcement schemes where possible.
- ❍ Minimize column spacing so that reasonably sized members can be designed to resist the design loads and increase the redundancy of the system. A practical upper level for column spacing is 30 feet for the levels of blast loads described herein.
- ❍ Minimize floor to floor heights. Unless there is an overriding architectural requirement, a practical limit is generally less than or equal to 16 feet.
- ❍ Use architectural or structural features that deny contact with exposed primary vertical load members in school lobbies. A minimum stand-off of at least 6 inches from these members is required.
- ❍ Minimize the use of venetian blinds and false ceilings, and locating equipment such as light fixtures, partitions, ductwork, and air conditioners above ceilings wherever possible. These items may become flying debris in the event of an explosion. Placing heavy equipment such as air conditioners near the floor rather than the ceiling is one idea for limiting this hazard; using exposed ductwork as an architectural device is another possibility.

3.3 BUILDING ENVELOPE

3.3.1 Building Exterior

The exterior envelope of the school building is the most vulnerable to an exterior explosive threat because it is the part of the building closest to the weapon. It also is a critical line of defense for protecting the occupants of the school building.

The design philosophy to be used here is that simpler is better. Generally simple geometries, with minimal ornamentation (which may become flying debris during an explosion) are recommended. If ornamentation is used, it is recommended that it consists of a lightweight material such as timber or plastic, which is less likely to become a projectile in the event of an explosion than, for example, brick, stone, or metal.

3.3.2 Exterior Wall Design

The exterior walls provide the first line of defense to prevent airblast pressures and hazardous debris from entering the school building. At a minimum, the objective of design is to ensure that these members fail in a flexible mode rather than in a brittle mode such as shear. The walls also need to be able to resist the loads transmitted by the windows and doors. Beyond ensuring a flexible failure mode, the exterior wall may be designed to resist the actual or reduced pressure levels of the defined threat. Special reinforcing and anchors should be provided around blast-resistant window and door frames.

Poured-in-place reinforced concrete will provide the highest level of protection, but solutions like pre-cast concrete, reinforced concrete masonry unit (CMU) block, and metal studs may also be used to achieve lower levels of protection.

For pre-cast panels, consider a minimum thickness of 5 inches with two-way reinforcing bars placed at spacing not greater than the thickness of the panel. Connections into the structure should provide as a straight a line of load transmittal as practical, using as few connecting pieces as possible.

For CMU block walls, use 8-inch block walls, fully grouted with vertical centered reinforcing bars placed in each cell and horizontal reinforcement at each layer. Connections into the structure should be able to resist the ultimate lateral capacity of the wall. A preferred system is to have a continuous exterior CMU wall that laterally bears against the floor system. For increased protection, consider using 12-inch blocks with two layers of reinforcement.

For metal stud systems, use metal studs back to back and mechanically attached, to minimize lateral torsion effects. To catch exterior cladding fragments, attach a wire mesh to the exterior side of the metal stud system. The supports of the wall are to be designed to resist the ultimate lateral capacity load of the system.

When designing schools in areas perceived as high risk, engineers and architects should consider the following recommendations:

- Substitute strengthened building walls and systems when stand-off distances cannot be accommodated.
- Use ductile materials capable of very large plastic deformations without complete failure.
- Design exterior walls to resist the actual pressures and impulses acting on the exterior wall surfaces from the threats defined for the school building.
- Design exterior walls to withstand the dynamic reactions from the windows.
- Design exterior shear walls to resist the actual blast loads predicted from the threats specified. Consider shear walls that are essential to the lateral and vertical load bearing system, and that also function as exterior walls, to be primary structures.
- Consider reinforced concrete wall systems in lieu of masonry or curtain walls to minimize flying debris in a blast.

- ❍ Reinforced wall panels can protect columns and assist in preventing progressive collapse, because the wall will assist in carrying the load of a damaged column.
- ❍ Give special consideration to construction types that reduce the potential for collapse where exterior walls are not designed for the full design loads.
- ❍ Consider use of sacrificial exterior wall panels to absorb blast.

3.3.3 Window Design

Window systems (e.g., glazing, frames, anchorage to supporting walls, etc.) on the exterior façade of a school building should be designed to mitigate the hazardous effects of flying glass during an explosion event. In an effort to protect school occupants, designers should integrate the features of the glass, connection of the glass to the frame (bite), and anchoring of the frame to the building structure to achieve a "balanced design." This means all the components should have compatible capacities and theoretically would all fail at the same pressure-pulse levels. In this way, the damage sequence and extent of damage are controlled. Table 3-1 presents six GSA glazing protection levels based on how far glass fragments would enter a space and potentially injure its occupants. Figure 3-4 depicts how far glass fragments could enter a structure for each GSA performance condition.

Table 3-1: Glazing Protection Levels Based on Fragment Impact Locations[1]

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 more than 3.3 feet from the window.
3b*	High	Low	Glazing cracks. Fragments enter space and land on floor no more than 10 feet 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 10 feet from the window at a height no greater than 2 feet above the floor.
5*	Low	High	Glazing cracks and window system fails catastrophically. Fragments enter space, impacting a vertical witness panel at a distance of no more than 10 feet from the window at a height greater than 2 feet above the floor.

* In conditions 2, 3a, 3b, 4 and 5, glazing fragments may be thrown to the outside of the protected space toward the detonation location.

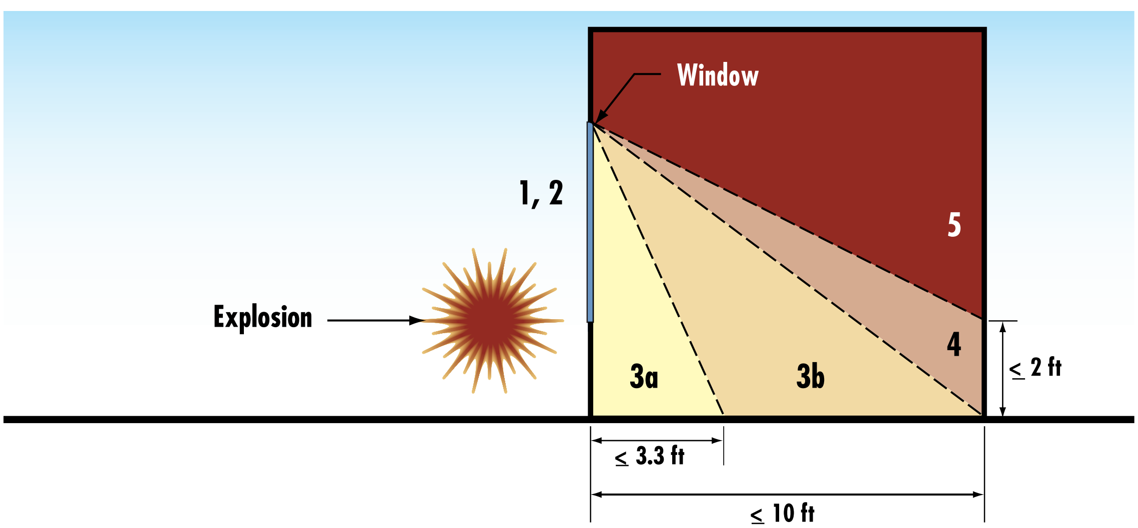


Figure 3-4 Side view of a test structure illustrating performance conditions of Table 3-2

[1] From GSA PBS-PQ100.1, *Facilities Standards for the Public Building Service*, June 14, 1996

The divide between performance conditions 3a and 3b can be equated to the "threshold of injury." The divide between performance conditions 4 and 5 can be equated to the "threshold of lethality." The GSA glazing performance conditions shown above correlate with the DoD levels of protection presented in Table 3-2.

Table 3-2: Correlation of GSA Glazing Performance Conditions and DoD Levels of Protection for New Buildings

GSA Glazing Performance Condition	Corresponding DoD Level of Protection for New Buildings
1	High
2	Medium
3a	Low
3b/4	Very Low
5	Below Antiterrorism (AT) Standards

FEMA 426, *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings,* contains a detailed description of window system design considerations. Although not all windows in a school can be designed to resist the full forces from very large explosive blast events, hardened window systems can provide significant protection for students, faculty, and staff. Preferred systems include: thermally tempered glass with a security film installed on the interior surface and attached to the frame; laminated thermally tempered glass; laminated heat strengthened, or laminated annealed glass; and blast curtains. Glazing systems that do not provide any protection include: untreated monolithic annealed or heat-strengthened glass and wire glass. Figure 3-5 depicts an unprotected window after a large explosion.

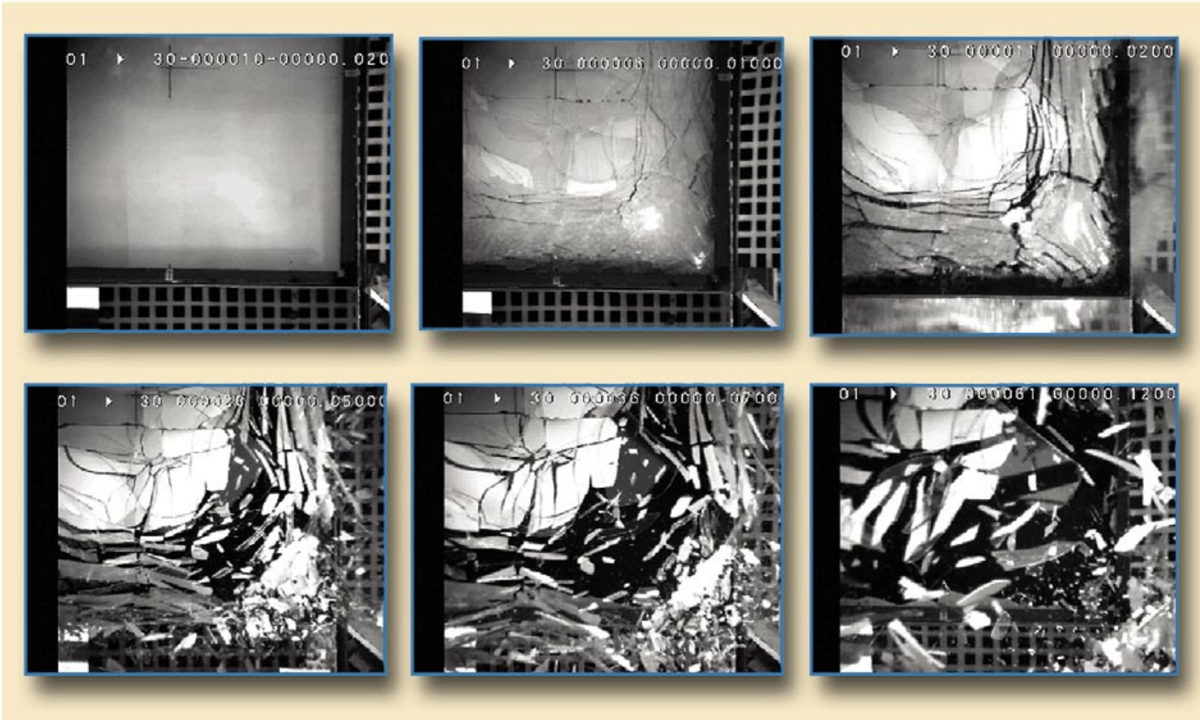


Figure 3-5 An unprotected window after a large explosion

General Guidelines for Windows and Glazing. General guidelines for windows and glazing include the following:

- Do not place windows adjacent to doors because, if the windows are broken, the door can be unlocked.
- In schools requiring high security, minimize the number and size of windows in a façade. If possible, limit the amount of glazed area in building facades to 15 percent. The amount of blast entering a space is directly proportional to the amount of opening on the facade.
- Consider using burglary- and ballistic-resistant glazing in high-risk school areas.
- Consider using laminated glass in place of conventional glass.
- Consider window safety laminate (such as mylar) or another fragment retention film (FRF) over glazing (properly installed) to reduce fragmentation.

- Consider placing guards, such as grills, screens, or meshwork, across window openings to protect against covert entry. Affix protective window guards firmly to the structure. Fire egress considerations must be judged against window guards.
- Position the operable section of a sliding window on the inside of the fixed section and secure it with a broomstick, metal rod, or similar device placed at the bottom of the track.
- Provide horizontal windows 6 feet above the finished floor to limit entry.
- Consider using steel window frames securely fastened or cement grouted to the surrounding structure.
- Minimize interior glazing in high-risk areas (e.g., lobbies, loading docks).

Mullion and Wall Design. The frame members connecting adjoining windows are referred to as mullions. These members may be designed using a static approach when the breaking strength of the window glass is applied to the mullion, or a dynamic load may be applied using the peak pressure and impulse values. Although the static approach may seem easier, it often yields a design that is not practical, because the mullion can become very deep and heavy, driving up the weight and cost of the window system. In addition, it may not be consistent with the overall architectural objectives of the project. A dynamic approach is likely to provide a section that meets the design constraints of the project. To accomplish this, a single-degree-of-freedom solution is often used. The governing equation of motion may be solved using numerical methods. There are also charts available for linearly decaying loads that circumvent the need to solve differential equations. These charts only require that the fundamental period of the mullion (including the tributary area of the window glass), the ultimate resistance force of the mullion, the peak pressure, and the equivalent linear decay time are known.

Peak lateral response of the mullion is to be limited to a 2-degree support rotation. Also, the displacement ductility is to be limited to a 4-

degree support rotation. As with frames, it is good engineering practice to limit the number of interlocking parts used for the mullion.

3.3.4 Doors

Door assemblies include the door, its frame, and anchorage to the building. As part of a balanced school design approach, exterior doors in high-risk buildings should be designed to withstand the maximum dynamic pressure and duration of the load from the design threat explosive blast. Other general door considerations for these types of buildings are as follows:

- ❍ Provide hollow steel doors or steel-clad doors with steel frames. Ensure the strength of the latch and frame anchor equals that of the door and frame.
- ❍ Consider blast-resistant doors for schools considered to be at high risk.
- ❍ Permit normal entry/egress through a limited number of doors, if possible, while accommodating emergency egress.
- ❍ Ensure that exterior doors into inhabited areas open outward. In addition to facilitating egress, by doing so, the doors will seat into the door frames in response to an explosive blast, increasing the likelihood that the doors will not enter the school building as hazardous debris.
- ❍ Replace externally mounted locks and hasps with internally locking devices because the weakest part of most door assemblies is the latching component.
- ❍ Locate hinges on interior or use exterior security hinges to reduce their vulnerability.
- ❍ Install emergency exit doors so that they facilitate only exiting movement.
- ❍ Consider using solid doors or walls as a backup for glass doors in foyers.
- ❍ Strengthen and harden the upright surfaces of a door jamb into which the door fits.

3.3.5 Roof System Design

Control access to school roofs to minimize the possibility of aggressors placing explosives or CBR agents there or otherwise threatening school occupants or critical infrastructure. Designers should consider the following:

- For new school buildings, eliminate all external roof access by providing access from internal stairways or ladders, such as in mechanical rooms.
- For existing school buildings, eliminate external access, where possible, or make roof access ladders removable, retractable, or lockable.
- Provide pitched roofs to allow deflection of explosives.
- Make school roof access hatches secure from intruders.
- Consider designing buildings with a sacrificial sloping roof that is above a protected ceiling (see Figure 3-6).

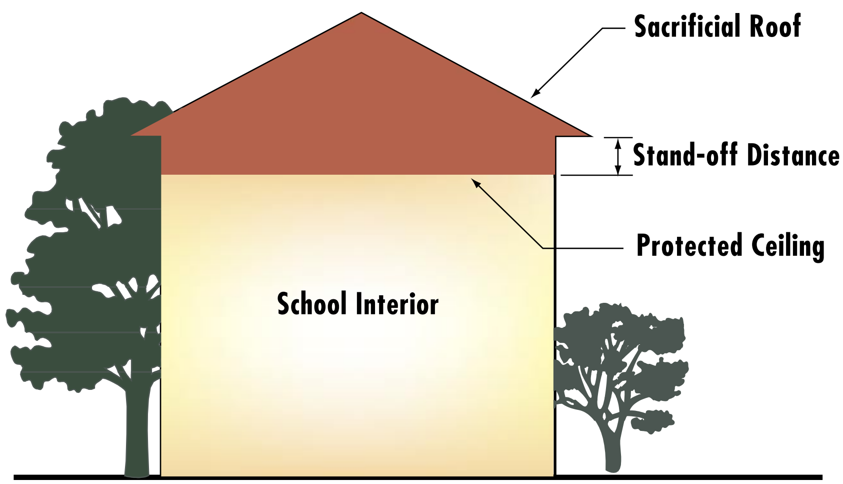


Figure 3-6 Sacrificial roof

3.4 MECHANICAL SYSTEMS

Mechanical systems design standards address limiting damage to critical infrastructure and protecting school building occupants against CBR threats. The primary goal of a mechanical system after a terrorist attack should be to continue to operate key life safety systems for school occupants. School designers should be aware that during an interior bombing event, smoke removal and control are of paramount importance. They should consider the fact that, if window glazing is hardened, a blast may not blow out windows, and smoke may be trapped in the school building. In the event of a blast, the available smoke removal system may be essential to smoke removal, particularly in large, open spaces. This equipment should be located away from high-risk areas such as loading docks and garages. The system controls and power wiring to the equipment should be protected. The system should be connected to emergency power to provide smoke removal. Smoke removal equipment should be provided with standalone local control panels that can continue to individually function in the event the control wiring is severed from the main control system.

Designers should consider locating components in less vulnerable areas, limiting access to mechanical systems, and providing a reasonable amount of redundancy. Specific considerations include the following:

- Avoid mounting plumbing, electrical fixtures, or utility lines on the inside of exterior school walls. When this is unavoidable, mount fixtures on a separate wall at least 6 inches from the exterior wall face.
- Avoid placing plumbing on the top of the roof deck of the school building.
- Avoid suspending plumbing fixtures and piping from the ceiling.
- Reduce the number of utility openings, manholes, tunnels, air conditioning ducts, filters, and access panels into the school structure.
- Protect school building operational control areas and utility feeds to lessen the negative effects of a blast.
- Design operational redundancies to survive all kinds of attacks.
- Use lockable systems for school utility openings and manholes where appropriate. Infrequently used utility covers/manholes

can be tack-welded as an inexpensive alternative to locking tamper-resistant covers.

Key HVAC System Considerations. The following HVAC design measures should be considered to mitigate the risk of CBR threats against school buildings. A more detailed discussion of HVAC design considerations is contained in FEMA 426 *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings* and FEMA 427 *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks.* HVAC protective actions are discussed in Chapter 5.

- Place intakes at the highest practical level on the school building. For protection against malicious acts, the intakes should also be covered by screens so that objects cannot be tossed into the intakes or into air wells from the ground (see Figures 3-7, 3-8, and 3-9). Such screens should be sloped to allow thrown objects to roll or slide off the screen, away from the intake. Many existing school buildings have air intakes that are located at or below ground level. For those that have wall-mounted or below-grade intakes close to the building, the intakes can be elevated by constructing a plenum or external shaft over the intake (see Figure 3-10).

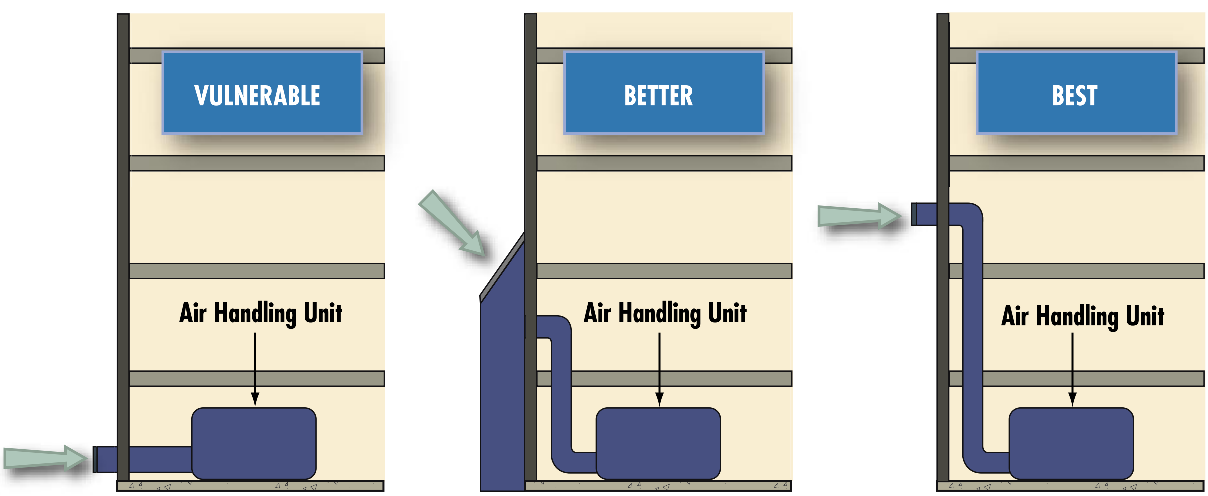


Figure 3-7 Example of protecting outdoor air intakes

SOURCE: CDC/NIOSH, PUBLICATION NO. 2002-139, *GUIDANCE FOR PROTECTING BUILDING ENVIRONMENTS FROM AIRBORNE CHEMICAL, BIOLOGICAL, OR RADIOLOGICAL ATTACKS*, MAY 2002.

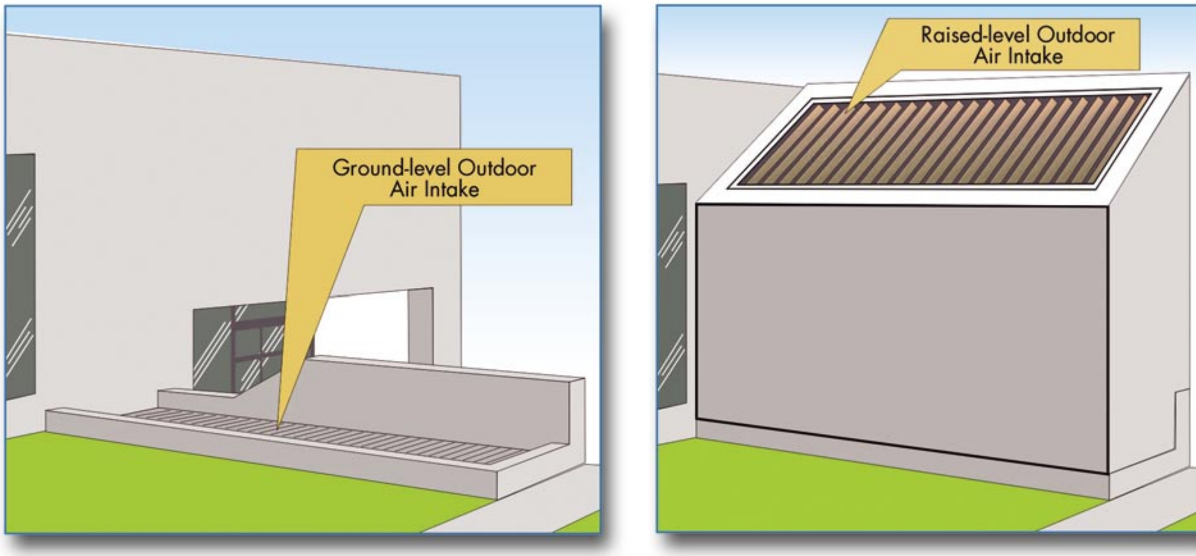


Figure 3-8 Another example of protecting air intakes

SOURCE: CDC/NIOSH, PUBLICATION NO. 2002-139, *GUIDANCE FOR PROTECTING BUILDING ENVIRONMENTS FROM AIRBORNE CHEMICAL, BIOLOGICAL, OR RADIOLOGICAL ATTACKS*, MAY 2002.

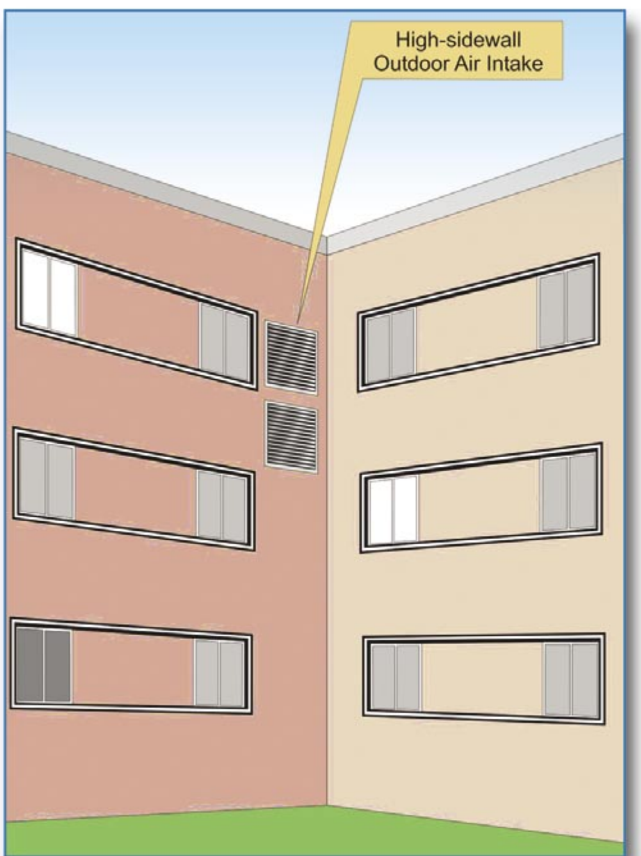


Figure 3-9
Example of elevated air intake

SOURCE: CDC/NIOSH, PUBLICATION NO. 2002-139, *GUIDANCE FOR PROTECTING BUILDING ENVIRONMENTS FROM AIRBORNE CHEMICAL, BIOLOGICAL, OR RADIOLOGICAL ATTACKS*, MAY 2002.

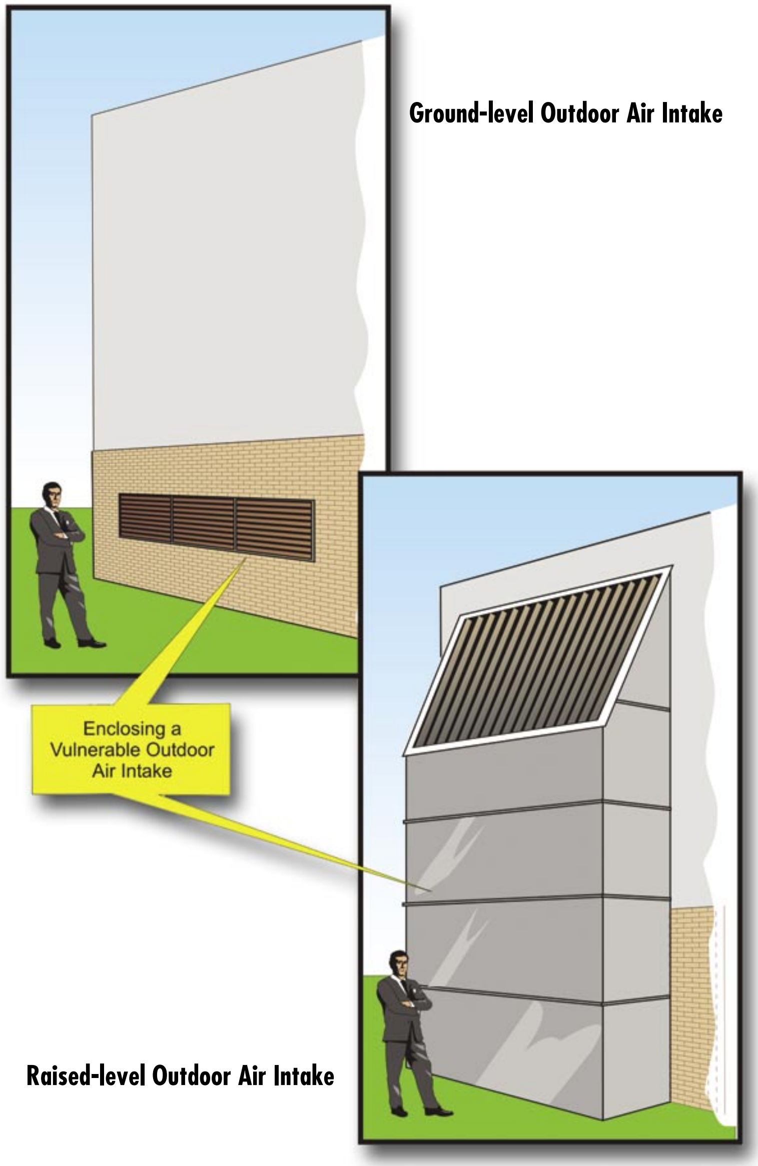


Figure 3-10
Example of enclosing an existing vulnerable air intake

SOURCE: CDC/NIOSH, PUBLICATION NO. 2002-139, *GUIDANCE FOR PROTECTING BUILDING ENVIRONMENTS FROM AIRBORNE CHEMICAL, BIOLOGICAL, OR RADIOLOGICAL ATTACKS*, MAY 2002.

- Provide protection for existing school buildings with air intakes below grade, at ground level, or wall-mounted outside secure areas, with physical security measures (e.g., placing fencing, surveillance cameras, and motion detectors around the intakes to facilitate monitoring by security personnel). These measures can help prevent malicious acts, but are less effective than elevating the intakes, because ground level releases under certain conditions can enter the intakes from points outside the area fenced or under surveillance.

- ❍ Maintain physical security on mechanical rooms to prevent the direct introduction of hazardous materials into the system of ducts that distributes air to the school building. This includes locking and controlling the access to all mechanical rooms containing HVAC equipment.

- ❍ Restrict access to school building operation systems by outside personnel. To deter tampering by outside maintenance personnel, a school staff member should escort these individuals throughout their service visit and should visually inspect their work before final acceptance of the service. Alternatively, schools can ensure the reliability of pre-screened service personnel from a trusted contractor.

- ❍ Restrict access to school building data. Information on building operations (including mechanical, electrical, vertical transport, fire and life safety, security system plans and schematics, and emergency operations procedures) should be controlled.

- ❍ Isolate school lobbies, mailrooms, loading docks, and storage areas. Lobbies, mailrooms (includes various mail processing areas), loading docks, and other entry and storage areas should be physically isolated from the rest of the building. These are areas where bulk quantities of CBR agents are likely to enter a school building.

- ❍ Consider "shelter-in-place" rooms or areas in schools, where people can stay in the event of an outdoor release. The goal is to create areas where outdoor air infiltration is very low. Usually such rooms will be in the inner part of the school in an area with no exterior windows if possible. The rooms should have doors that are fairly effective at preventing airflow and should contain staging supplies such as duct tape and plastic to help further seal the areas from the hallways. Typically, restrooms are a bad choice, because they have exhaust ducts that lead directly to the outside. Opening and closing a conventional hinged door can pump large amounts of air into the room; if practical, replace the door with a code compliant sliding door to reduce this effect. Additionally, it may be possible to provide purified air to the safe area through modifications to the HVAC system. For more information, see Chapters 5 and 6.

- Ducted returns offer limited access points to introduce a CBR agent. The return vents can be placed in conspicuous locations throughout a school, reducing the risk of an agent being secretly introduced into the return system. Non-ducted return air systems commonly use hallways or spaces above suspended ceilings as a return-air path or plenum. CBR agents introduced at any location above the suspended ceiling in a ceiling plenum return system will probably migrate back to the HVAC unit and be redistributed to occupied areas. Schools should be designed to minimize mixing between air-handling zones, which can be partially accomplished by limiting shared returns.

3.5 ELECTRICAL SYSTEMS

The major security functions of the electrical system are to maintain power to essential school services, especially those required for life safety and evacuation. When designing a school building, architects and engineers should consider providing lighting and surveillance to deter criminal activities, and provide emergency communications. They should also consider the following recommendations:

- Emergency and normal electric panels, conduits, and switchgear should be installed separately, at different locations, and as far apart as possible. Electric distribution should also run at separate locations.
- Emergency generators should be located away from loading docks, entrances, and parking. More secure locations include the roof, protected grade level, and protected interior areas.
- Main fuel storage for generators should be located away from loading docks, entrances, and parking. Access should be restricted and protected (e.g., locks on caps and seals).

- Fuel tanks should be mounted near the generator, given the same protection as the generator, and sized to store an appropriate amount of fuel. A battery and/or UPS could be a viable alternative for a smaller school.
- Conduits and lines should be installed outside to allow a trailer-mounted generator to connect to the school's electrical system. If tertiary power is required, other methods include generators and feeders from alternative substations.
- Emergency power should be provided for emergency lighting in school restrooms, egress routes, and any meeting room without windows.
- School building access points should be illuminated to aid in threat detection.
- Self-contained battery lighting should be provided in stairwells and for exit signs.
- Suspending electrical conduits from the ceiling should be avoided.
- Adequate lighting of perimeters and parking areas should be provided to aid in visual surveillance and to support the use of CCTV.

3.6 FIRE PROTECTION SYSTEMS

The fire protection system inside the school building should maintain life safety protection after an incident and allow for safe evacuation of the building when appropriate. Although fire protection systems are designed to perform well during fires, they are not traditionally designed to survive bomb blasts. Fire protection system considerations include the following:

- A school's fire protection water system should be protected from single-point failure in case of a blast event. The incoming line should be encased, buried, or located 50 feet away from high-risk areas. The interior mains should be looped and sectionalized.

- To increase the reliability of the fire protection system, a dual pump arrangement should be considered, with one electric pump and one diesel pump. The pumps should be located away from each other.

- All school security locking arrangements on doors used for egress must comply with requirements of NFPA 101, Life Safety Code.

3.7 COMMUNICATIONS SYSTEMS

Designers should consider the following:

- **Redundant communications.** The school should have a second telephone service to maintain communications in case of an incident. A base radio communications system with antenna should be installed in the stairwell, and portable sets distributed on floors. This is the preferred alternative.

- **Radio telemetry.** Distributed antennas could be located throughout the school facility if required for emergency communications through wireless transmission of data.

- **Alarm and information systems.** Alarm and information systems should not be collected and mounted in a single conduit, or even collocated. Circuits to various parts of the school building should be installed in at least two directions and/or risers. Low voltage signal and control copper conductors should not share conduits with high voltage power conductors. Fiber-optic conductors are generally preferred over copper.

- **Empty conduits.** Empty conduits and power outlets can be provided for possible future installation of security control equipment.

- **Mass notification.** All inhabited school buildings should have a timely means to notify occupants of threats and instruct them what to do in response to those threats. School buildings should have a capability to provide real-time notification of building occupants and people in the immediate vicinity of the building during emergency situations. The information relayed should be specific enough to determine the appropriate response actions.

3.8 PHYSICAL SECURITY SYSTEMS

Physical security is defined as that part of security concerned with physical measures designed to safeguard people and to prevent unauthorized access to equipment, certain areas of the school building, and key documents. These days, all security operations face new and complex physical security challenges across the full spectrum of operations.

Although security technologies are not the answer to all school security problems, if applied appropriately, they can enhance security, free up administrators for more appropriate work, and sometimes can save money. At a non-educational building, a typical approach to physical security is:

For example, if someone is breaking into a school facility, it is necessary to have a means of detection so that information can be provided to appropriate authorities. Next, the intruder must be delayed as long as possible so that the response force may arrive. Finally, someone, such as the police, must respond to the incident to catch the intruder. For a school, the National Institute for Justice[2] has recommended expanding this model as shown below:

[2] National Institute of Justice Research Report NCJ 178265, *The Appropriate and Effective Use of Security Technologies in U.S. Schools,* September 1999.

This educational approach emphasizes deterrence by instituting measures both before and after an event to convince perpetrators not to do whatever they are considering. Although, the efficacy of deterrence for high-risk terrorist tactics is questionable, schools have a broad spectrum of threats to consider with any physical security system. Schools are also unique in that they generally have the authority and opportunity to establish consequences for incidents that involve students and occur on school grounds. Figure 3-11 depicts some considerations for the design of a school security system and Figure 3-12 shows examples of physical security devices.

For schools requiring greater security, some general measures are contained in the National Institute of Justice Research Report NCJ 178265, *The Appropriate and Effective Use of Security Technologies in U.S. Schools,* September 1999.

Deterrence	Detection	Delay	Response/ Investigation	Consequences
• Fencing • Signs • Video cameras • ID checks • Weapon screenings • Officer on campus • Anti-graffiti sealers • Random locker searches • Vehicle checks • Drug dogs	• Sensors • Drug dogs • Bomb dogs • Cameras • Duress alarms • Weapon screenings • Crime stopper "hotlines" • Drug swipes • Staff	• Bolted down equipment • Locked doors • Fences	• Security personnel • Law enforcement • Viewing videotapes • Rewards	• Suspension/ expulsion • Mandatory work on campus • Citation or arrest • Judicial system

Figure 3-11 Considerations for the design of a new security system

SOURCE: NATIONAL INSTITUTE OF JUSTICE RESEARCH REPORT NCJ 178265, *THE APPROPRIATE AND EFFECTIVE USE OF SECURITY TECHNOLOGIES IN U.S. SCHOOLS*, SEPTEMBER 1999.

Figure 3-12 Physical security devices

Obviously, when considering any physical security measure for a school, it is important to balance its use with the risk of creating a "bunker" or "prison" atmosphere that is not conducive to learning. The measures recommended in this chapter should be applied judiciously and in concert with the threat assessment depicted in Chapter 1, and also with any risk perceived by school administrators.

3.9 SUMMARY OF BUILDING ENVELOPE MITIGATION MEASURES

A general spectrum of building envelope mitigation measures ranging from the least protection, cost, and effort going to the greatest protection, cost, and effort is provided below. Detailed discussions of individual measures can be found earlier in this chapter. Please note this is a nominal ranking of mitigation measures. In practice, the effectiveness and cost of individual mitigation measures may deviate from this example based on specific applications.

- Ensure that all school exterior doors into inhabited areas open outward. Ensure emergency exit doors only facilitate exiting.
- Secure school roof access hatches from the interior. Prevent public access to building roofs.
- Restrict access to school building operation systems.
- Conduct periodic training of school HVAC maintenance and operation staff.
- Evaluate HVAC control options.
- Install empty conduits for future school security control equipment during initial construction or major renovation.
- Do not mount plumbing, electrical fixtures, or utility lines on the inside of exterior walls.
- Minimize interior glazing near high-risk a reas.
- Establish school emergency plans, policies, and procedures.
- Establish written plans for school evacuation and sheltering in place.
- Illuminate school access points.
- Restrict access to school building information.
- Secure HVAC intakes and mechanical rooms.
- Limit the number of doors used for normal entry/egress.
- Lock all utility access openings.
- Provide emergency power for emergency lighting in school restrooms, egress routes, and any meeting room without windows.
- Install an internal public address system.
- Stagger interior doors and offset interior and exterior doors.
- Eliminate hiding places.
- Install a second and separate telephone service.
- Install radio telemetry distributed antennas throughout the facility.
- Use a badge identification system for school access.
- Install a CCTV surveillance system in areas where needed.
- Install an electronic security alarm system in areas where needed.
- Install rapid response and isolation features into school HVAC systems.
- Use interior barriers to differentiate levels of security.
- Avoid eaves and overhangs or harden to withstand blast effects.
- Locate utility systems away from likely areas of potential attack.
- Install call buttons at key public contact areas.
- Install emergency and normal electric equipment at different locations.
- Avoid exposed structural elements.

Continued on next page

- Reinforce foyer walls.
- Use architectural features to deny contact with exposed primary vertical load members.
- Isolate school lobbies, mailrooms, loading docks, and storage areas.
- Locate stairwells remotely. Do not discharge stairs into lobbies, parking, or loading areas.
- Elevate school HVAC fresh-air intakes.
- Create "shelter-in-place" rooms or areas.
- Separate HVAC zones. Eliminate leaks and increase school building air tightness.
- Install blast-resistant doors or steel doors with steel frames.
- Physically separate unsecured areas from the main school building.
- Install HVAC exhausting and purging systems.
- Connect interior non-load bearing walls to structure with non-rigid connections.
- Use structural design techniques to resist progressive collapse of school buildings.
- Treat exterior shear walls as primary structures.
- Orient glazing perpendicular to the primary façade facing uncontrolled vehicle approaches.
- Use reinforced concrete wall systems in lieu of masonry or curtain walls.
- Ensure active fire system is protected from single-point failure in case of a blast event.
- Establish school's ground floor elevation 4 feet above grade.
- Avoid re-entrant corners on the school building exterior.
- Issue CBR personal protective equipment.
- Design exterior walls to resist blast.
- Design school facilities with a sacrificial sloping roof above a protected ceiling.
- Upgrade glazing - laminated glass, safety laminates, FRF, etc.
- Install a 24-hour on-site monitoring center.
- Install HVAC filtering and pressurization.
- Install HVAC CBR real-time monitoring detectors.

3.10 RECOMMENDATIONS BASED ON THE HOMELAND SECURITY ADVISORY SYSTEM

Table 3-3 presents recommendations for safety/security measures linked to the DHS Threat Advisory Level. Chapter 6 of the U.S. Department of Education (DOE) *Practical Information on Crisis Planning: A Guide for Schools and Communities* contains similar recommendations.

Table 3-3: Safety/Security Recommendations

DHS Threat Advisory Level	Recommended Actions
Green – Low Risk	❍ Develop school written emergency plans ❍ Coordinate emergency plans with local, state, and federal plans ❍ Ensure selected staff members take a Red Cross cardiopulmonary resuscitation (CPR)/automated external defibrillator (AED) and first aid course ❍ Develop emergency communications plan and lists ❍ Conduct crisis management and communications training for all employees ❍ Disseminate emergency procedures and plans to parents ❍ Develop and implement visitor control procedures ❍ Obtain emergency supplies and equipment ❍ Obtain copies of Terrorism: *Preparing for the Unexpected* brochure from the local Red Cross chapter
Blue – Guarded	❍ Complete recommended actions at lower level ❍ Review and update emergency plans ❍ Upgrade to appropriate visitor control procedures ❍ Review and update emergency communication plan and lists ❍ Inventory and restock emergency supplies ❍ Conduct safety training /emergency drills following the school's written emergency plan
Yellow - Elevated	❍ Complete recommended actions at lower level ❍ Be alert to suspicious activity and report it to the proper authorities ❍ Assess increased risk with public safety officials ❍ Reassess school security measures ❍ Verify that emergency supplies are stocked and ready ❍ Review field trip decisions ❍ Update employee emergency call lists and review callback process with employees ❍ Test alternate communications capabilities ❍ Increase communications with parents and community via web site and e-mail distributions ❍ Distribute copies of Terrorism: *Preparing for the Unexpected* brochure from the local Red Cross chapter and send it home with students in grades K-12, faculty, and staff

Table 3-3: Safety/Security Recommendations (continued)

DHS Threat Advisory Level	Recommended Actions
Orange - High	❍ Complete recommended actions at lower level ❍ Consider canceling outside activities ❍ Prepare to handle inquiries from anxious parents and media ❍ Review and implement increased security measures • Limit parking near school buildings • Restrict visitor access ❍ Discuss children's fears concerning possible terrorist attacks ❍ Review sporting event and extracurricular activity decisions ❍ Place school and district crisis response teams on standby alert status
Red - Severe	❍ Complete recommended actions at lower level ❍ Follow local and/or Federal Government instructions ❍ Coordinate with local and state officials to consider school openings and closings ❍ Listen to radio/TV for current information/instructions ❍ Review and implement increased security measures • Further limiting parking to increase stand-off • Posting/increasing security staff ❍ Activate command and support centers if appropriate ❍ Continue staff, parent, and community communications ❍ Coordinate parent-child reunification process, if necessary ❍ Ensure mental health counselors are available for students, faculty, and staff

3.11 SCHOOL SAFETY EMERGENCY MANAGEMENT PLAN

The DHS has designated the DOE as the lead agency for security related to schools. The DOE has published a guide, *Practical Information on Crisis Planning: A Guide for Schools and Communities*, May 2003, that is intended to give schools, districts, and communities the critical concepts and components of good crisis planning, stimulate thinking about crisis preparedness process, and provide examples of promising practices. Additional information is also available from the National Advisory Committee on Children and Terrorism (NACCT).

The DOE recommends each school crisis plan address four major areas: mitigation/prevention, preparedness, response, and recovery.

- **Mitigation/Prevention:**

  - Conduct an assessment of each school building. Identify those factors that put the building, students, faculty, and staff at greater risk, such as proximity to rail tracks that regularly transport hazardous materials or facilities that produce highly toxic material or propane gas tanks, and develop a plan for reducing the risk. This can include plans to evacuate students away from these areas in times of crisis and to reposition propane tanks or other hazardous materials away from school buildings.
  - Work with businesses and factories in close proximity to the school to ensure that the school's crisis plan is coordinated with their crisis plans.
  - Ensure that a process is in place for controlling access and egress to the school. Require all persons who do not have authority to be in the school to sign in.
  - Review traffic patterns, and where possible, keep cars, buses, and trucks away from school buildings.
  - Review landscaping, and ensure that buildings are not obscured by overgrowth of bushes or shrubs where contraband can be placed or persons can hide.

- **Preparedness:**

  - Have site plans for each school building readily available and ensure they are shared with first responders and agencies responsible for emergency preparedness.
  - Ensure there are multiple evacuation routes and rallying points. First or second evacuation site options may be blocked or unavailable at the time of the crisis.
  - Practice responding to crisis on a regular basis.

- Ensure a process is established for communicating during a crisis.
- Inspect equipment to ensure it operates during crisis situations.
- Have a plan for discharging students. Remember that, during a crisis, many parents and guardians may not be able to get to the school to pick up their child. Make sure every student has a secondary contact person and contact information readily available.
- Have a plan for communicating information to parents and for quelling rumors. Cultivate relationships with the media ahead of time, and identify a Public Information Officer (PIO) to communicate with the media and the community during a crisis.
- Work with law enforcement officials and emergency preparedness agencies on a strategy for sharing key parts of the school crisis plans.

❍ **Response:**

- Identify the type of crisis that is occurring and determine the appropriate response.
- Develop a command structure for responding to a crisis. The roles and responsibilities for educators, law enforcement and fire officials, and other first responders in responding to different types of crisis need to be developed, coordinated, reviewed, and approved.
- Maintain communications among all relevant staff.

❍ **Recovery:**

- Return to the business of teaching and learning as soon as possible.
- Identify and approve a team of credentialed mental health workers to provide mental health services to faculty and students after a crisis. Understand that recovery takes place over time and that the services of this team may be needed over an extended time period.

- Ensure that the team is adequately trained.
- The plan needs to include notification of parents on actions that the school intends to take to help students recover from the crisis.

3.12 EMERGENCY PLANS AND TRAINING

Every school should have a school safety emergency management plan developed in partnership with public safety agencies, including law enforcement, fire, public health, mental health and local emergency preparedness agencies. The plan should address fire, and natural and manmade disasters. A school's plan should be tailored to address the unique circumstances and needs of the individual school, and should be coordinated and integrated with community plans and the plans of local emergency preparedness agencies.

These plans should also consider CBR attack scenarios and the associated procedures for communicating instructions to building occupants, identifying suitable shelter-in-place areas (if they exist), identifying appropriate use and selection of personal protective equipment (i.e., clothing, gloves, respirators) and directing emergency evacuations. Individuals developing emergency plans and procedures should recognize that there are fundamental differences between chemical, biological, and radiological agents. In general, chemical agents will show a rapid onset of symptoms, while the response to biological and radiological agents will be delayed. Issues such as designated areas and procedures for chemical storage, HVAC control or shutdown, and communications with school occupants and emergency responders, should all be addressed. The plans should be as comprehensive as possible, but, as described earlier, protected by limited and controlled access. When appropriately developed, these plans, policies, and procedures can have a major impact upon school occupant survivability in the event of a CBR release.

Staff training, particularly for those with specific responsibilities during an event, is essential and should cover both internal and external events. Holding regularly scheduled practice drills, similar to the common fire drill, allows for plan testing, as well as student and key staff rehearsal of the plan, and increases the likelihood for success in an actual event. School officials should ensure that training is provided to staff that operate and maintain the school's HVAC system. This training should include the procedures to be followed in the event of a suspected CBR agent release. Development of current, accurate HVAC diagrams and HVAC system labeling protocols should be addressed. These documents can be of great value in the event of a CBR release.

This chapter discusses blast effects, potential school damage, injuries, levels of protection, stand-off distance, and predicting blast effects. Specific blast design concerns and mitigation measures are discussed in Chapters 2 and 3. Explosive events have historically been a favorite tactic of terrorists for a variety of reasons and this is likely to continue into the future. The DoD, GSA, and DOS have considerable experience with blast effects and blast mitigation. However, many architects and building designers do not have such experience. For additional information on explosive blast, see FEMA 426, *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings*, and FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks*. See sidebar for important reference material on explosive blast.

The following additional references are recommended:

- Air Force Engineering and Services Center. Protective Construction Design Manual, ESL-TR-87-57. Prepared for Engineering and Services Laboratory, Tyndall Air Force Base, FL. (1989).
- U.S. Department of the Army. Security Engineering, TM 5-853 and Air Force AFMAN 32-1071, Volumes 1, 2, 3, and 4. Washington, DC, Departments of the Army and Air Force. (1994).
- U.S. Department of the Army. Structures to Resist the Effects of Accidental Explosions, Army TM 5-1300, Navy NAVFAC P-397, AFR 88-2. Washington, DC, Departments of the Army, Navy, and Air Force. (1990).
- U.S. Department of Energy. A Manual for the Prediction of Blast and Fragment Loading on Structures, DOE/TIC 11268. Washington, DC, Headquarters, U.S. Department of Energy. (1992).
- U.S. General Services Administration. GSA Security Reference Manual: Part 3 Blast Design and Assessment Guidelines. (2001).
- Biggs, John M. Introduction to Structural Dynamics. McGraw-Hill. (1964).
- The Institute of Structural Engineers. The Structural Engineer's Response to Explosive Damage. SETO, Ltd., 11 Upper Belgrave Street, London SW1X8BH. (1995).
- Mays, G.S. and Smith, P.D. Blast Effects on Buildings: Design of Buildings to Optimize Resistance to Blast Loading. Thomas Telford Publications, 1 Heron Quay, London E14 4JD. (1995).
- National Research Council. Protecting Buildings from Bomb Damage. National Academy Press. (1995).

4.1 BLAST EFFECTS

An explosion is an extremely rapid release of energy in the form of light, heat, sound, and a shock wave. A shock wave consists of highly compressed air traveling radially outward from the source at supersonic velocities. As the shock wave expands, pressures decrease rapidly (with the cube of the distance) and, when it meets a surface that is in line-of-sight of the explosion, it is reflected and amplified by a factor of up to thirteen. Pressures also decay rapidly over time (i.e., exponentially) and have a very brief span of existence, measured typically in thousandths of a second, or milliseconds. Diffraction effects, caused by corners of a building, may act to confine the air-blast, prolonging its duration. Late in the explosive event, the shock wave becomes negative, creating suction. Behind the shock wave, where a vacuum has been created, air rushes in, creating a powerful wind or drag pressure on all surfaces of the building. This wind picks up and carries flying debris in the vicinity of the detonation. In an external explosion, a portion of the energy is also imparted to the ground, creating a crater and generating a ground shock wave analogous to a high-intensity, short-duration earthquake.

In the context of other hazards (e.g., earthquakes, winds, or floods), an explosive attack has the following distinguishing features:

- The intensity of the pressures acting on a targeted building can be several orders of magnitude greater than these other hazards. It is not uncommon for the peak pressure to be in excess of 100 pounds per square inch (psi) on a building in an urban setting for a vehicle weapon parked along the curb. At these pressure levels, major damages and failure are expected.
- Explosive pressures decay extremely rapidly with distance from the source. Therefore, the damages on the side of the building facing the explosion may be significantly more severe than on the opposite side. As a consequence, direct air-blast damages tend to cause more localized damage.
- The duration of the event is very short, measured in thousandths of a second, or milliseconds. This differs from earthquakes and wind gusts, which are measured in seconds, or sustained wind or flood situations, which may be measured in hours. Because of this, the mass of the structure has a strong mitigating effect on the response because it takes time to mobilize the mass of the structure. By the time the mass is mobilized, the loading is gone, thus mitigating the response. This is the opposite of earthquakes, whose imparted forces are roughly in the same timeframe as the response of the building mass, causing a resonance effect that can worsen the damage.

4.1.1 Building Damage

The extent and severity of damage and injuries in an explosive event cannot be predicted with perfect certainty. Past events show that the unique specifics of the failure sequence for a building significantly affect the level of damage. Despite these uncertainties, it is possible to give some general indications of the overall level of damage and injuries to be expected in an explosive event, based on the size of the explosion, distance from the event, and assumptions about the construction of the building.

Damage due to the air-blast shock wave may be divided into direct air-blast effects and progressive collapse. Direct air-blast effects are damage caused by the high-intensity pressures of the air-blast close in to the explosion and may induce the localized failure of exterior walls, windows, floor systems, columns, and girders. Progressive collapse is discussed in Section 3.2.

The air-blast shock wave is the primary damage mechanism in an explosion. The pressures it exerts on building surfaces may be several orders of magnitude greater than the loads for which the building is designed. The shock wave also acts in directions that the building may not have been designed for, such as upward on the floor system. In terms of sequence of response, the air-blast first impinges on the weakest point in the vicinity of the device closest to the explosion, typically the exterior envelope of the building. The explosion pushes on the exterior walls at the lower stories and may cause wall failure and window breakage. As the shock wave continues to expand, it enters the structure, pushing both upward and downward on the floors (see Figure 4-1).

Floor failure is common in large-scale vehicle-delivered explosive attacks, because floor slabs typically have a large surface area for the pressure to act on and a comparably small thickness. In terms of the timing of events, the building is engulfed by the shockwave and direct air-blast damage occurs within tens to hundreds of milliseconds from the time of detonation. If progressive collapse is initiated, it typically occurs within seconds.

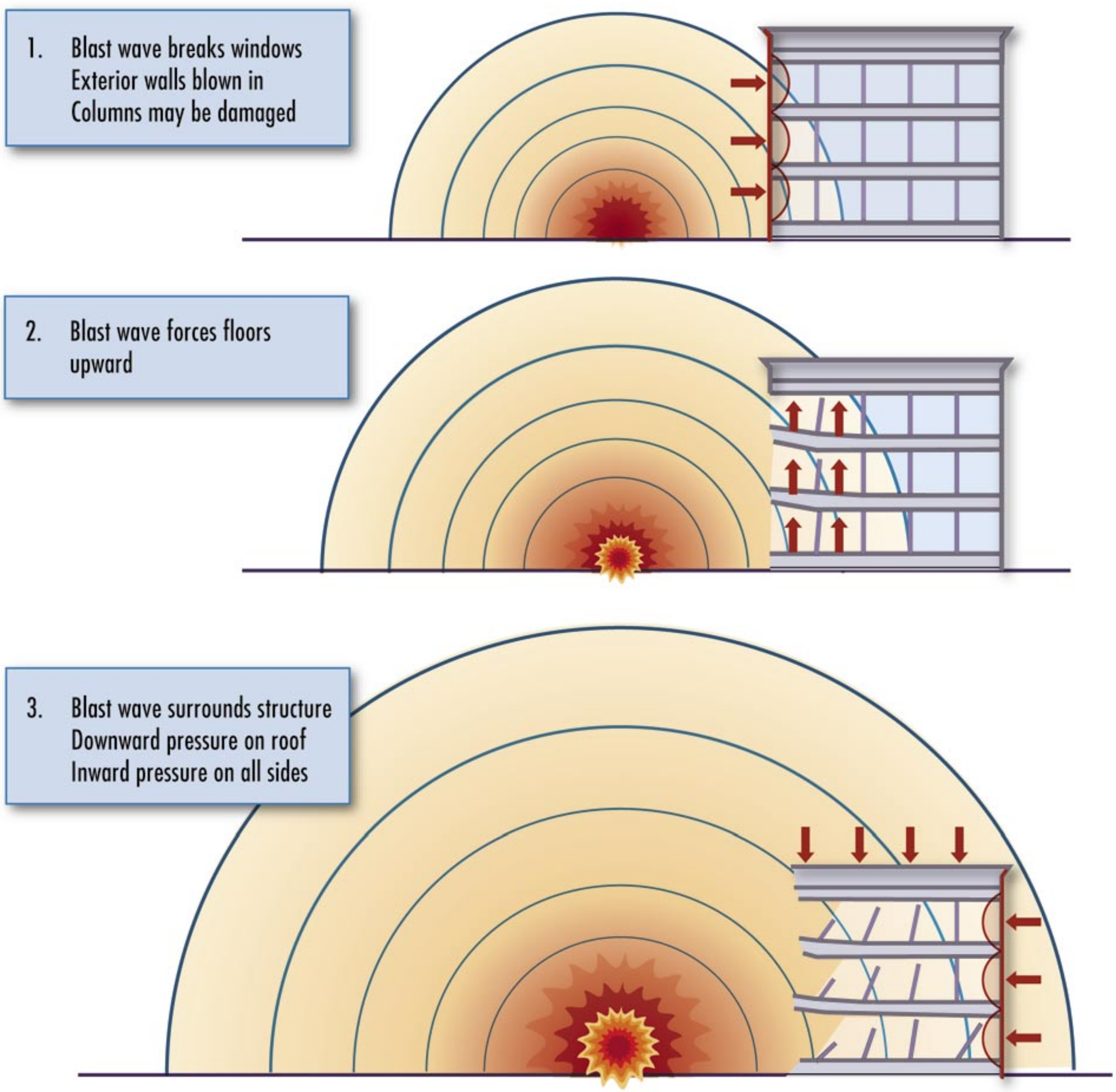


Figure 4-1 Blast pressure effects on a structure

Glass is often the weakest part of a building, breaking at low pressures compared to other components such as the floors, walls, or columns. Past incidents have shown that glass breakage may extend for miles in large external explosions. High-velocity glass fragments have been shown to be a major contributor to injuries in such incidents. For incidents within downtown city areas, falling glass poses a major hazard to passersby on the sidewalks below and prolongs post-incident rescue and cleanup efforts by leaving tons of glass debris on the street. Specific glazing design considerations are discussed in Chapter 3.

4.1.2 Casualties and Injuries

Blast can cause significant casualties. During the bombing of the Murrah Federal Building, 168 people were killed. Severity and type of injury patterns incurred in explosive events may be related to the level of structural damage. The high pressure of the air-blast that enters through broken windows can cause eardrum damage and lung collapse. As the air-blast damages the building components in its path, missiles are generated that cause impact injuries. Airborne glass fragments typically cause penetration or laceration-type injuries. Larger fragments may cause non-penetrating, or blunt trauma, injuries. Finally, the air-blast pressures can cause occupants to be bodily thrown against objects or to fall. Lacerations due to high-velocity flying glass fragments have been responsible for a significant portion of the injuries received in explosion incidents. In the bombing of the Murrah Federal Building in Oklahoma City, for instance, 40 percent of the survivors in the building cited glass as contributing to their injuries. Within nearby buildings, laceration estimates ranged from 25 percent to 30 percent.

4.1.3 Levels of Protection

The amount of explosive and the resulting blast dictate the level of protection required to prevent a building from collapsing or minimize injuries and deaths. Table 4-1 shows how the DoD correlates levels of protection with potential damage and expected injuries. The GSA and the Interagency Security Committee (ISC) also use the level of protection concept. However, wherein DoD has five levels, they have established four levels of protection. The GSA and ISC levels of protection can be found in GSA PBS-P100, *Facilities Standards for the Public Buildings* Service, November 2000, Section 8.6.

Table 4-1: DoD Minimum Antiterrorism (AT) Standards for New Buildings

Level of Protection	Potential Structural Damage	Potential Door and Glazing Hazards	Potential Injury
Below AT standards	Severely damaged – frame collapse/massive destruction. Little left standing.	Doors and windows fail and result in lethal hazards	Majority of personnel suffer fatalities.
Very Low	Heavily damaged – onset of structural collapse. Major deformation of primary and secondary structural members, but progressive collapse is unlikely. Collapse of non-structural elements.	Glazing will break and is likely to be propelled into the building, resulting in serious glazing fragment injuries, but fragments will be reduced. Doors may be propelled into rooms, presenting serious hazards.	Majority of personnel suffer serious injuries. There are likely to be a limited number (10 percent to 25 percent) of fatalities.
Low	Damaged – unrepairable. Major deformation of non-structural elements and secondary structural members and minor deformation of primary structural members, but progressive collapse is unlikely.	Glazing will break, but fall within 1 meter of the wall or otherwise not present a significant fragment hazard. Doors may fail, but they will rebound out of their frames, presenting minimal hazards.	Majority of personnel suffer significant injuries. There may be a few (<10 percent) fatalities.
Medium	Damaged – repairable. Minor deformations of non-structural elements and secondary structural members and no permanent deformation in primary structural members.	Glazing will break, but will remain in the window frame. Doors will stay in frames, but will not be reusable.	Some minor injuries, but fatalities are unlikely.
High	Superficially damaged. No permanent deformation of primary and secondary structural members or non-structural elements.	Glazing will not break. Doors will be reusable.	Only superficial injuries are likely.

SOURCE: THE DoD UNIFIED FACILITIES CRITERIA (UFC), *DoD MINIMUM ANTITERRORISM STANDARDS FOR BUILDINGS*, UFC 4-010-01, 31 JULY 2002

The levels of protection above can roughly be correlated for conventional construction without any blast hardening to the following incident pressures as shown in Table 4-2.

Table 4-2: Correlation of DoD Level of Protection to Incident Pressure

Level of Protection	Incident Pressure (psi)
High	1.1
Medium	1.8
Low	2.3

Figure 4-2 shows an example of a range-to-effect chart that indicates the distance or stand-off to which a given size bomb will produce a given effect (see Section 4.2). This type of chart can be used to display the blast response of a building component or window at different levels of protection. It can also be used to consolidate all building response information to assess needed actions if the threat weapon-yield changes. For example, an amount of explosives are stolen and indications are that they may be used against a specific building. A building-specific range-to-effect chart will allow quick determination of the needed stand-off for the amount of explosives in question, once the explosive weight is converted to trinitrotoluene (TNT) equivalence. Given an explosive weight and a stand-off distance, Figure 4-2 can be used to predict damage for nominal building construction.

For design purposes, large scale truck bombs typically contain 10,000 pounds or more of TNT equivalent, depending on the size and capacity of the vehicle used to deliver the weapon. Vehicle bombs that utilize vans down to small sedans typically contain 4,000 to 500 pounds of TNT equivalent, respectively. A briefcase bomb is approximately 50 pounds, and a pipe bomb is generally in the range of 5 pounds of TNT equivalent. Research performed as part of the threat assessment process should identify bomb sizes used in the locality or region. Security consultants have valuable information that may be used to evaluate the range of likely charge weights.

Figures 4-3 and 4-4 show blast effects predictions for a high school based on a typical car bomb, and a typical large truck bomb detonated in the school's parking lot, respectively. A computer-based GIS was used to analyze the school's vehicular access and circulation pattern to determine a reasonable detonation point for a vehicle bomb. Structural blast analysis was then performed using nominal explosive weights and a nominal school structure. The results are shown in Figures 4-3 and 4-4. The red ring indicates the area in which structural damage is predicted. The orange and yellow rings indicate predictions for lethal injuries and severe injuries from glass, respectively. Please note that nominal inputs were used in this analysis and they are not a predictive examination.

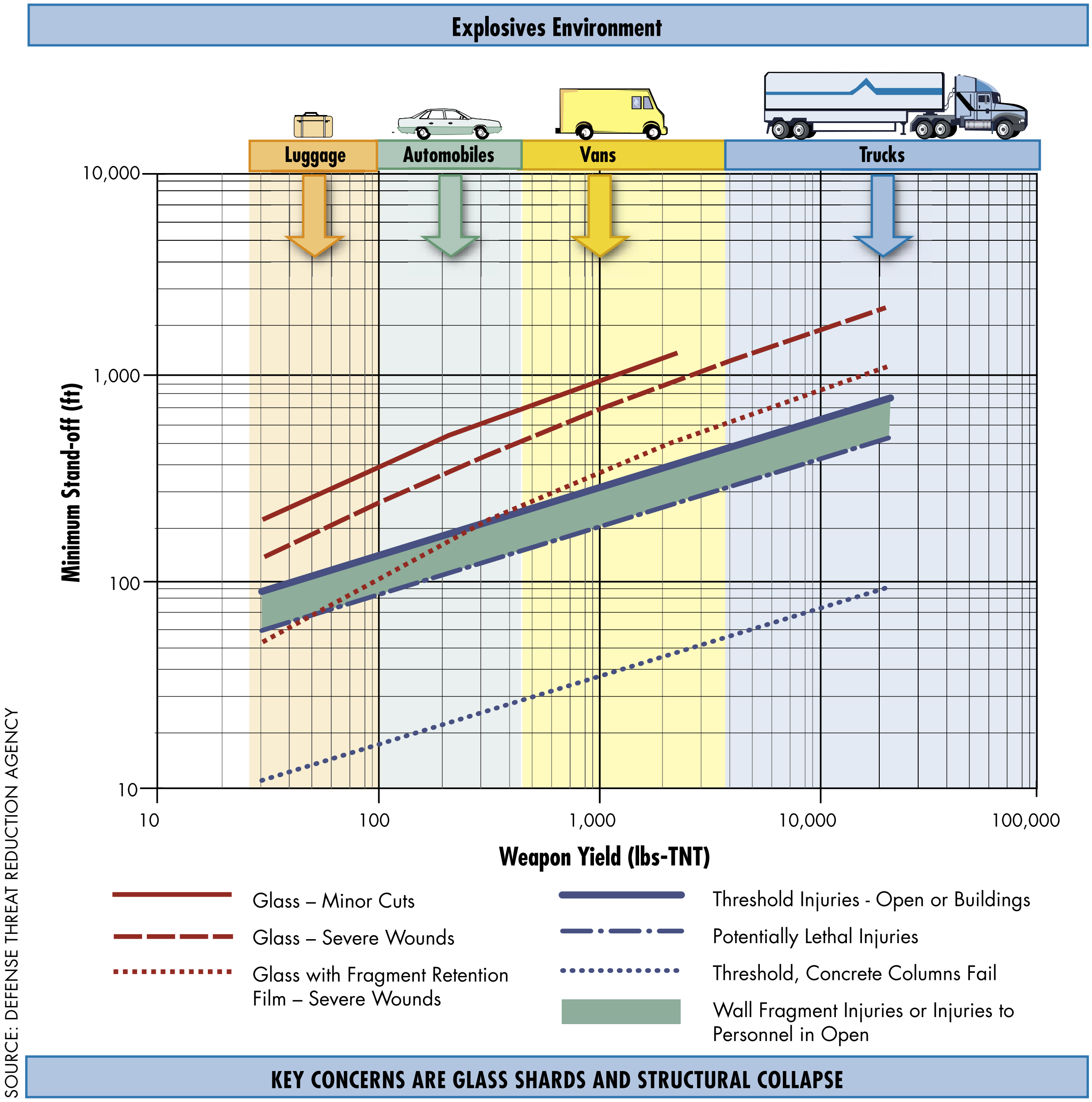


Figure 4-2 Explosives environments - blast range to effects

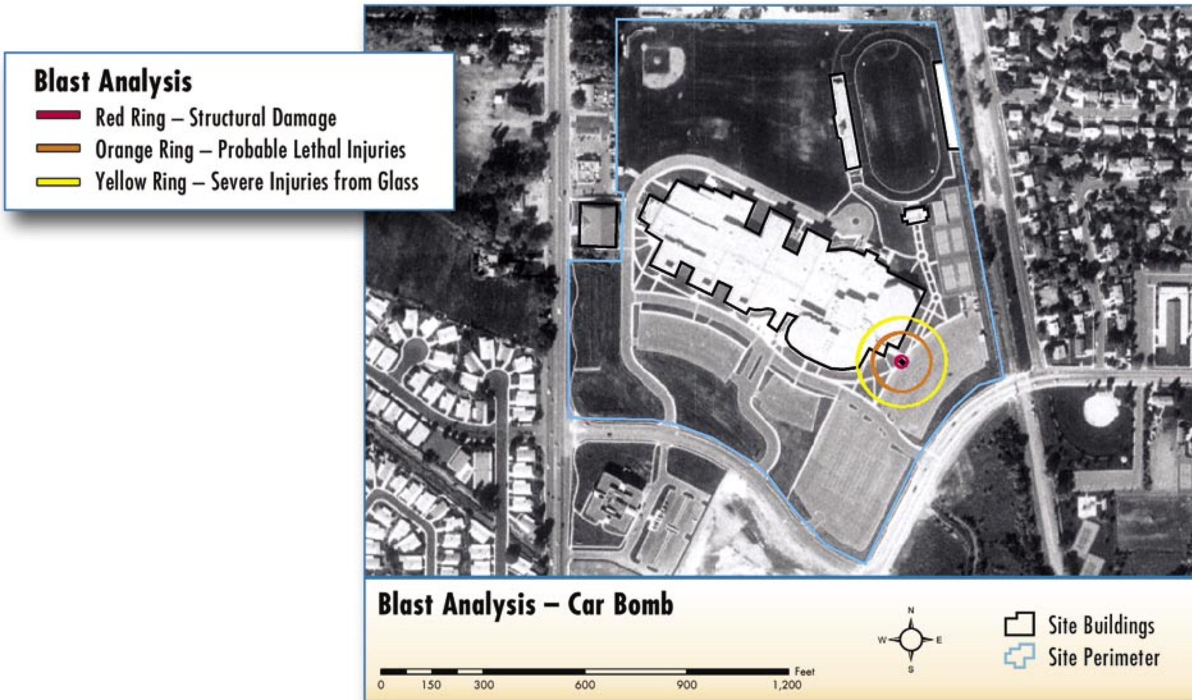


Figure 4-3 Blast analysis of a high school for a typical car bomb detonated in the school's parking lot

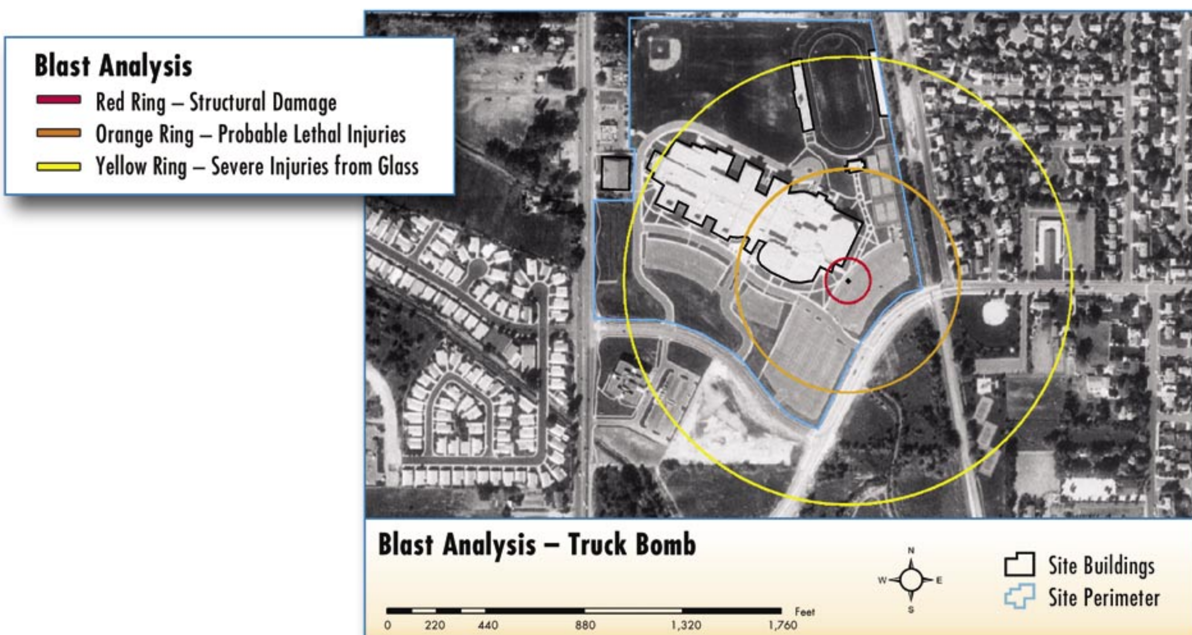


Figure 4-4 Blast analysis of a high school for a typical large truck bomb detonated in the school's parking lot

In the case of a stationary vehicle bomb, knowing the size of the bomb (TNT equivalent in weight), its distance from the structure, how the structure is put together, and the materials used for walls, framing, and glazing allows the designer to determine the level of damage that will occur and the level of protection achieved. Whether an existing building or a new construction, the designer can then select mitigation measures as presented in this chapter and Chapters 2 and 3 to achieve the level of protection desired.

4.2 STAND-OFF DISTANCE AND THE EFFECTS OF BLAST

Energy from a blast decreases rapidly over distance. In general, the cost to provide asset protection will decrease as the distance between an asset and a threat increases, as shown in Figure 4-5. However, increasing stand-off also requires more land and more perimeter to secure with barriers, resulting in an increased cost not reflected in Figure 4-5. As stand-off increases, blast loads generated by an explosion decrease and the amount of hardening necessary to provide the required level of protection decreases.

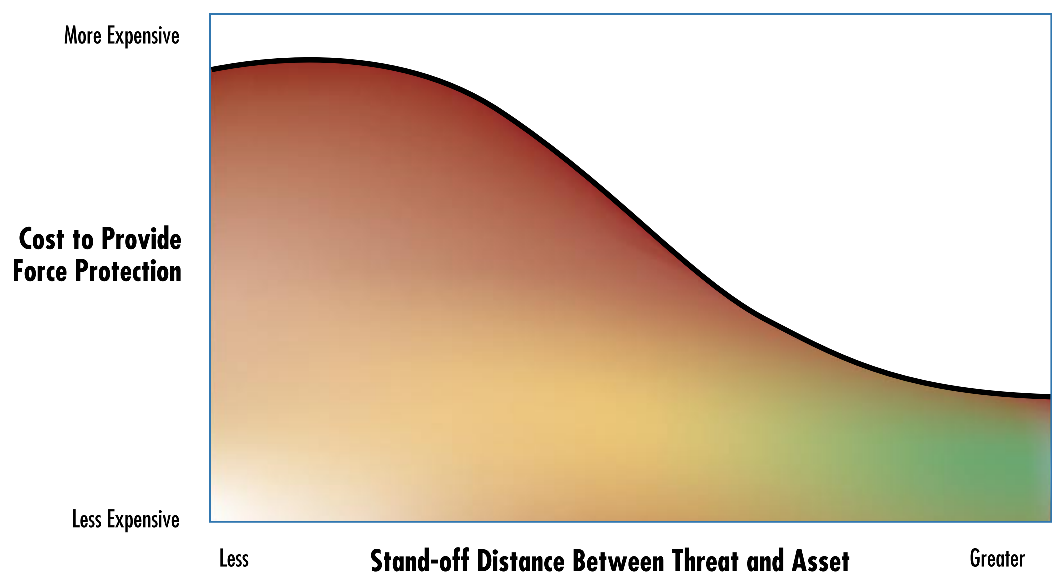


Figure 4-5 Relationship of cost to stand-off distance
SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

The critical location of the weapon is a function of the site, the building layout, and the security measures in place. For vehicle bombs, the critical locations are considered to be at the closest point that a vehicle can approach on each side, assuming that all security measures are in place. Typically this is a vehicle parked along the curb directly outside the building, or at the entry control point where inspection takes place. For internal weapons, location is dictated by the areas of the building that are publicly accessible (e.g., lobbies, corridors, auditoriums, cafeterias, or gymnasiums). Range or stand-off is measured from the center of gravity of the charge located in the vehicle or other container to the building component under consideration.

Defining appropriate stand-off distance for a given building component to resist explosive blast effects is difficult. Often in urban settings, it is either not possible or practical to obtain appropriate stand-off distance. Adding to the difficulty is the fact that defining appropriate stand-off distance requires a prediction of the explosive weight of the weapon. In the case of terrorism, this is tenuous at best.

The DoD prescribes minimum stand-off distances based on the required level of protection. Where minimum stand-off distances are met, conventional construction techniques can be used with some modifications. In cases where the minimum stand-off cannot be achieved, the building must be hardened to achieve the required level of protection (see the DoD UFC – *DoD Minimum Antiterrorism Standards for Buildings*, UFC 4-010-01, 31 July 2002).

The first step in predicting blast effects on a building is to predict blast loads on the structure. Because blast pressure pulse varies based on stand-off distance, angle of incidence, and reflected pressure over the exterior of the building, the blast load predictions can be very complex. Consultants may use sophisticated methods such as Computational Fluid Dynamics (CFD) computer programs to predict blast loads. These complex programs require special equipment and training to run.

In most cases, especially for design purposes, more simplified methods may be used by blast consultants to predict blast loads. Tables of pre-determined values (see *GSA Security Reference Manual: Part 3 – Blast Design & Assessment Guidelines,* July 31, 2001) or computer programs may be used such as: [1]

- ATBLAST (GSA)
- CONWEP (U.S. Army Engineer Research and Development Center)

Figure 4-6 provides a quick method for predicting the expected overpressure (expressed in pounds per square inch or psi) on a building for a specific explosive weight and stand-off distance. Enter the x-axis with the estimated explosive weight a terrorist might use and the y-axis with a known stand-off distance from a building. By correlating the resultant effects of overpressure with other data, the degree of damage that the various components of a building might receive can be estimated. The vehicle icons in Figure 4-6 indicate the relative size of the vehicles that might be used to transport various quantities of explosives.

The analysis of structures subjected to the effects of an explosion is very complex and requires an understanding of structural engineering, dynamics, strengths of materials, and specialized training in explosive effects. Such analysis should be performed by engineers who can conduct a complex analysis that is both time-dependent and accounts for non-linear behavior. In the absence of such an analysis of a specific structure, it is possible to provide rough approximations of building damages to be expected in an explosive event. Table 4-3 provides basic estimates of incident pressures at which different types of damage generally occur to buildings based on the incident pressures determined in Figure 4-6.

[1] For security reasons, the distribution of these computer programs is limited.

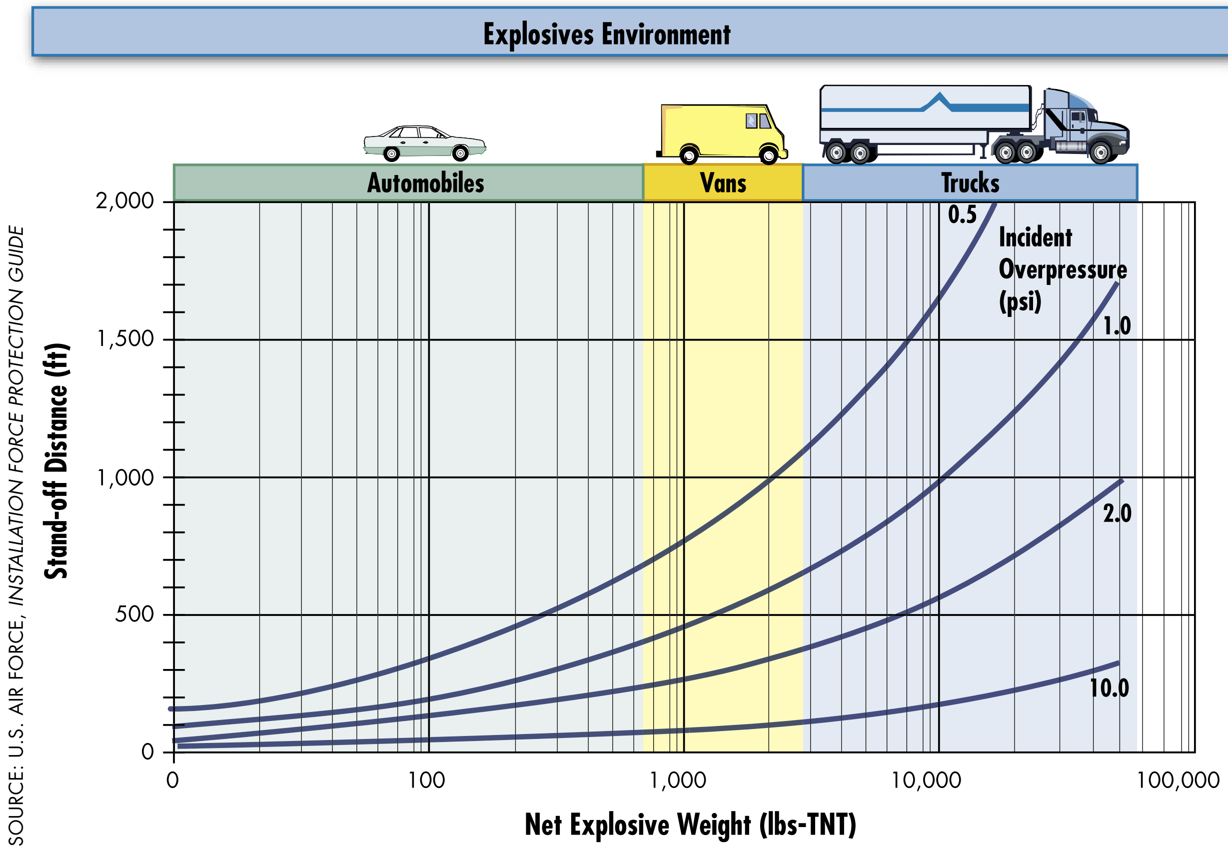


Figure 4-6 Incident overpressure measured in pounds per square inch, as a function of stand-off distance and net explosive weight (pounds-TNT)

Table 4-3: Damage Approximations

Damage	Incident Overpressure (psi)
Typical window glass breakage	0.15 – 0.22
Minor damage to some buildings	0.5 – 1.1
Panels of sheet metal buckled	1.1 – 1.8
Failure of concrete block walls	1.8 – 2.9
Collapse of wood framed buildings	Over 5.0
Serious damage to steel framed buildings	4 – 7
Severe damage to reinforced concrete structures	6 – 9
Probable total destruction of most buildings	10 – 12

SOURCES: *EXPLOSIVE SHOCKS IN AIR*, KINNEY & GRAHM, 1985; *FACILITY DAMAGE AND PERSONNEL INJURY FROM EXPLOSIVE BLAST*, MONTGOMERY & WARD, 1993; AND *THE EFFECTS OF NUCLEAR WEAPONS*, 3RD EDITION, GLASSTONE & DOLAN, 1977.

This chapter is based on guidance from the Centers for Disease Control and Protection (CDC)/National Institute for Occupational Safety and Health (NIOSH) and the DoD and presents protective measures and actions to safeguard the occupants of a school building from CBR threats. Evacuation, sheltering in place, personal protective equipment, air filtration and pressurization, and exhausting and purging will be discussed, as well as CBR detection.[1] Additionally, CBR design mitigation measures are discussed in Chapters 3 and 6, and Appendix C contains information on chemical and biological agent characteristics. FEMA 426 *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings* contains detailed information on CBR threats.

Although the likelihood of a direct attack against a school is very low, recent terrorist events have increased interest in the vulnerability of all types of buildings to CBR threats. Of particular concern are building HVAC systems, because they can become an entry point and distribution system for airborne hazardous contaminants. Even without special protective systems, buildings can provide protection in varying degrees against airborne hazards that originate outdoors. Conversely, the hazards produced by a release inside a building can be much more severe than a similar release outdoors. Because buildings allow only a limited exchange of air between indoors and outdoors, not only can higher concentrations occur when there is a release inside, but hazards may persist longer indoors.

Airborne hazardous contaminants can be gases, vapors, or aerosols (small solid and liquid particles). Most biological and radiological agents are aerosols, whereas most chemical warfare agents are gaseous.

[1] This chapter includes a number of protective measures that are included for informational purposes only. It is not the intention of FEMA to endorse any particular product or protective measure.

After the presence of an airborne hazard is detected, there are five possible protective actions for a building and its occupants. In increasing order of complexity and cost, these actions are:

1. Evacuation
2. Sheltering in Place
3. Personal Protective Equipment
4. Filtering and Pressurization
5. Exhausting and Purging

These actions are implemented, singly or in combination, when a hazard is present or known to be imminent. To ensure these actions will be effective, a school safety emergency plan specific to each school, as well as training and familiarization for occupants, is required (see Sections 3.11 and 3.12). Exhausting and purging is listed last because it is usually the final action after any airborne hazard incident.

5.1 EVACUATION

Evacuation is the most common protective action taken when an airborne hazard, such as smoke or an unusual odor, is perceived in a building. In most cases, existing plans for fire evacuation apply. Orderly evacuation is the simplest and most reliable action for an internal airborne hazard, but may not be the best action in all situations, especially in the case of an external CBR release or plume, particularly one that is widespread. If the area covered by the plume is too large to rapidly and safely exit, sheltering in place should be considered. If a CBR agent has infiltrated the building and evacuation is deemed not to be safe, the use of protective hoods may be appropriate. Two considerations in non-fire evacuation are: 1) to determine if the source of the airborne hazard is internal or external to the building; and 2) to determine if evacuation may lead to other risks. Also, evacuation and assembly of occupants should be on the upwind side of the building and at least 100 feet away, because any airborne hazard escaping the structure will be carried downwind.

5.2 SHELTERING IN PLACE

Typically, buildings offer little protection to occupants from airborne hazards outside the structure because outdoor air must be continuously introduced to provide a comfortable, healthy indoor environment. However, a school can provide substantial protection against agents released outdoors if the flow of fresh air is filtered/cleaned, or temporarily interrupted or reduced. Interrupting the flow of fresh air is the principle applied in the protective action known as sheltering in place. Additional information can be found in Section 3.4 and Chapter 6 of this primer.

The need for schools to consider sheltering in place is demonstrated in Figure 5-1, which depicts the results of modeling a chemical dispersion from a rail line assuming local prevailing winds. Note that the chemical plume travels directly over a nominal elementary school.

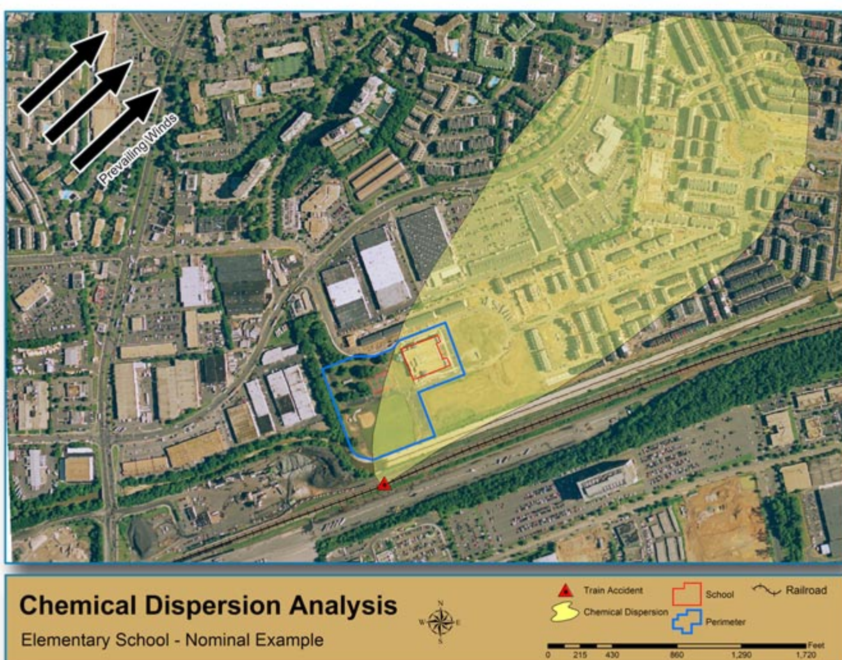


Figure 5-1 Example of chemical dispersion

The advantage of sheltering in place is that it can be implemented rapidly. The disadvantage is that its protection is variable and diminishes with the duration of the hazard. Sheltering requires that two distinct actions be taken without delay to maximize the passive protection a school building provides:

- First, reduce the indoor-outdoor air exchange rate before the hazardous plume arrives. This is achieved by closing all windows and doors, and turning off all fans, air conditioners, and combustion heaters.

- Second, increase the indoor-outdoor air exchange rate as soon as the hazardous plume has passed. This is achieved by opening all windows and doors, and turning on all fans to ventilate the building.

The level of protection that can be attained by sheltering in place is substantial, but it is less than can be provided by high-efficiency filtration of the fresh air introduced into the building. The amount of protection varies with:

- **The building's air exchange rate.** The tighter the school building (i.e., the lower the air exchange rate), the greater the protection it provides. In most cases, air conditioners and combustion heaters cannot be operated while sheltering in place because operating them increases the indoor-outdoor exchange of air.

- **The duration of exposure**. Protection varies with time, diminishing as the time of exposure increases. Sheltering in place is, therefore, suitable only for exposures of short duration, roughly 2 hours or less, depending on conditions.

- **Purging or period of occupancy.** How long students, faculty, and staff remain in the building after the hazardous plume has passed also affects the level of protection. Because the school building slowly purges contaminants that have entered it, at some point during plume passage, the concentration inside exceeds the concentration outside. Maximum protection is attained by increasing the air exchange rate after plume passage or by exiting into clean air.

- **Natural filtering.** Some filtering occurs when the agent is deposited in the school shell or upon interior surfaces as air passes into and out of the building. The tighter the school building, the greater the effect of this natural filtering.

In a home, taking the actions required for sheltering (i.e., closing windows and doors, and turning off all air conditioners, fans, and combustion heaters) is relatively simple. Doing so in a school may require more time and planning. All air handling units must be turned off and any dampers for outside air must be closed. Procedures for a protective action plan, therefore, should include:

- Identifying all air handling units, fans, and the switches needed to deactivate them.

- Identifying cracks, seams, joints, and pores in the building shell to be temporarily sealed to further reduce outside air infiltration. Keeping emergency supplies, such as duct tape and polyethylene sheeting, on hand.

- Identifying procedures for purging after an internal release (i.e., opening windows and doors, turning on smoke fans, air handlers, and fans that were turned off) to exhaust and purge the building.

- Identifying school safe rooms (i.e., interior rooms having a lower air exchange rate – see Chapter 6) that may provide a higher level of passive protection. It may be desirable to go to a predetermined sheltering room (or rooms) and:

    - Shut and lock all windows and doors
    - Seal any windows and vents with plastic sheeting and duct tape

- Seal the door(s) with duct tape around the top, bottom, and sides
- Firmly pack dampened towels along the bottom of each door
- Turn on a TV or radio that can be heard within the shelter and listen for further instructions
- When the "all clear" is announced, open windows and doors

Although sheltering is for protection against an external release, it is possible, but more complex, to shelter in place on one or more floors of a multi-story school building after an internal release has occurred on a single floor. Important considerations for use of sheltering in place are that stairwells must be isolated by closed fire doors, elevators must not be used, and clear evacuation routes must remain open if evacuation is required. Escape hoods may be needed if the only evacuation routes are through contaminated areas.

One final consideration for sheltering in place is that students, faculty, and staff cannot be forced to participate. During an event, some building emergency plans call for making a concise information announcement, and then giving occupants 3 to 5 minutes to proceed to the sheltering area or evacuate the building before it is sealed. It is important to develop a plan in cooperation with likely participants and awareness training programs that include discussions of sheltering in place and events (CBR attacks, hazardous material releases, or natural disasters) that might make sheltering preferable to evacuation. Training programs and information announcements during an event should be tailored to help students, faculty, and staff to make informed decisions.

5.3 PERSONAL PROTECTIVE EQUIPMENT

A wide range of individual protection equipment is available, including respirators, protective hoods, protective suits, CBR detectors, and decontamination equipment.

Of particular note, new models of universal-fit escape hoods have been developed for short-duration "escape-only" wear to protect against chemical agents, aerosols (including biological agents), and some toxic industrial chemicals. These hoods are compact enough to be stored in desks or to be carried on the belt. They should be stored in their sealed pouches and opened only when needed. Most of these hoods form protective seals at the neck and do not require special fitting techniques or multiple sizes to fit a large portion of the population. Training is required to use the hoods properly. Depending on hood design, the wearer must bite on and breathe through a mouth bit or use straps to tighten a nose cup around the nose and mouth (see Figure 5-2). Escape hoods should be considered, but may not be an effective or efficient proposed solution for use in schools, under current threats.

SOURCE: MSA INTERNATIONAL

Figure 5-2 Universal-fit escape hood

There are no government standards for hoods intended for protection against the malicious use of chemical or biological agents. In selecting an escape hood, a purchaser should, therefore, require information on laboratory verification testing. Plans should be made for training, fitting, storing, and maintaining records relative to storage life, and there should be procedures for instructing building occupants about when to put on the hoods. Wearing a hood can cause physiological strain and may cause panic or stress that could lead to respiratory problems in some people. Finally, it should be recognized that no single selection of personal protective equipment is effective against every possible threat. Selection must be tied to specific threat/hazard characteristics.

5.4 AIR FILTRATION AND PRESSURIZATION

Among the various protective measures for school buildings, high-efficiency air filtration/cleaning provides the highest level of protection against an outdoor release of hazardous materials. It can also provide continuous protection, unlike other approaches for which protective measures are initiated upon detecting an airborne hazard. Chapter 6 and FEMA 426 *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings* discuss air filtration in detail.

Two basic methods of applying air filtration to buildings are external filtration and internal filtration. External filtration involves drawing air from outside, filtering and/or cleaning it, and discharging the air inside the building or protected zone. This provides a higher level of protection, but involves substantially higher costs. Internal filtration involves drawing air from inside the building, filtering and/or cleaning it, and discharging the air back inside the building.

The relative levels of protection of the two methods can be illustrated in terms of protection factor, and the ratio of external dose and internal dose (concentration integrated over time). External filtration systems with high-efficiency filters can yield protection factors greater than 100,000. For internal filtration, the protection factors are likely to be less and are highly variable. The protection of internal filtration varies with a number of factors, including those listed in Section 5.2, the efficiency of the filter, flow rate of the filter unit, and size of the room or building in which the filter unit operates.

5.5 EXHAUSTING AND PURGING

Turning on building ventilation fans and smoke-purge fans is a protective action for purging airborne hazards from the building and reducing the hazard to which school occupants are exposed, but it is mainly useful when the source of the hazard is indoors.

Purging must be carefully applied with regard to the location of the source and the time of the release. It must be clear that the source of the hazard is inside the school building and, if not, purging should not be attempted. If the hazardous material has been identified before release or immediately upon release, purging should not be employed, because it may spread the hazardous material throughout the school building or HVAC zone. In this case, all air handling units should be turned off to isolate the hazard while evacuating or temporarily sheltering in place.

Additionally, the ventilation system and smoke purge fans can be used to purge the building following an external release after the hazard outdoors has dissipated, and it has been confirmed that the agent is no longer present near the school building.

5.6 CBR DETECTION

Most strategies for protecting students, faculty, staff, and visitors from airborne hazards will require a means of detection (i.e., determining that a hazard exists). Although effective and inexpensive devices are widely available to detect, for example, smoke and carbon monoxide, there are no detectors that can rapidly alert occupants to a broad range of chemical and biological hazards.

Chemical detection technology has improved vastly since Operation Desert Storm, where many military detection systems experienced high false alarm rates, but biological detection technology has not matured as fast. Biological signatures are not as distinctive as chemical signatures and can take 30 minutes or more to detect. Biological detection systems are expensive and generally require trained specialists to operate. Current chemical detectors work in approximately 10 seconds; furthermore, wide varieties of efficient radiological detectors have been developed for the nuclear industry and are commercially available.

Chemical Detectors. Driven largely by a desire to protect workers from toxic vapors in industrial environments, considerable information is known on the toxicity of chemical warfare agents, which often have dual uses in industry. A variety of detection technologies exist, ranging from inexpensive manual point detection devices (e.g., paper strips and calorimetric tubes) utilizing basic chemical reactions to trigger color changes, to sophisticated detection systems utilizing advanced technologies.

Chemical agents do not possess universal properties that permit detection by any single method. Therefore, most chemical detectors are designed to detect specific agents or a group of related agents. Most broad range detection systems actually combine several different sensors utilizing different technologies and can be very expensive and complex. Nevertheless, today there are numerous commercially available chemical detectors. The most capable detectors utilize ion mobility spectrometry (IMS), surface acoustic wave (SAW), or gas chromatograph/mass spectrometer (GC/MS) technologies to detect chemical agents and toxic industrial materials (TIMs).

Figure 5-3
An IMS chemical detector designed for installation in HVAC systems
SOURCE: SMITHS DETECTION

Today, there are commercially available IMS detection systems that will detect most chemical agents and many TIMs (see Figure 5-3). They are suitable for integration into a building ventilation system, can interface with HVAC control systems, have reasonable maintenance requirements (every 3 months), low false alarm rates, and can be programmed to detect specific chemical agents.

Biological Detectors. The current state of biological detection technology is very different from that of chemical agent detection technology. In general, most biological detection systems are currently in the research and early development stages. There are some commercially available devices that have limited utility (responding only to a small number of agents) and are generally high cost items. Because commercially available biological warfare (BW) detection systems and/or components exhibit limited utility in detecting and identifying BW agents and are also costly, it is strongly recommended that purchasers be very careful when considering any device that claims to detect BW agents.

5.7 INDICATIONS OF CBR CONTAMINATION

Most hazardous chemicals have warning properties that provide a practical means for detecting a hazard and initiating protective actions. Such warning properties make chemicals perceptible; for example, vapors or gases can be perceived by the human senses (i.e., smell, sight, taste, or irritation of the eyes, skin, or respiratory tract) before serious effects occur. The distinction between perceptible and imperceptible agents is not an exact one. The concentrations at which a person can detect an odor vary from person to person, and these thresholds also vary relative to the concentration that can produce immediate, injurious effects.

Most of the industrial chemicals and chemical-warfare agents are readily detectable by smell. Soldiers in World Wars I and II were taught to identify, by smell, such agents as mustard, phosgene, and chlorine, and this detection method proved effective for determining when to put on and take off a gas mask. An exception is the chemical-warfare agent Sarin, which is odorless and colorless in its pure form and, therefore, imperceptible. Among the most common toxic industrial chemicals, carbon monoxide is one of the few that is imperceptible. Because it is odorless and colorless, it causes many deaths in buildings each year (see Section 6.2.1).

Biological agents are also imperceptible and there are no detection devices that can determine their presence in the air in real time. Current methods for detecting bacterial spores, such as anthrax, require a trained operator and expensive equipment. It is not currently possible to base protective responses to biological agents on detection.

Researchers are working on a prototype device to automatically and continuously monitor the air for the presence of bacterial spores. The device would continuously sample the air and use microwaves to trigger a chemical reaction, the intensity of which would correspond to the concentration of bacterial spores in the sample. If an increase in spore concentration is detected, an alarm similar to a smoke detector would sound and a technician would respond and use traditional sampling and analysis to confirm the presence of anthrax spores. Researchers hope the device response time will be fast enough to help prevent widespread contamination.

In the absence of a warning property, people can be alerted to some airborne hazards by observing symptoms or effects in others. This provides a practical means for initiating emergency plans, because the susceptibility to hazardous materials varies from person to person. The concentrations of airborne materials may also vary substantially within a given building or room, producing a hazard that may be greater to some occupants than to others.

Other warning signs of a hazard may involve seeing and hearing something out of the ordinary, such as the hiss of a rapid release from a pressurized cylinder. Awareness of warning properties, signs, and symptoms in other people is the basis of an emergency plan (see Sections 3.11 and 3.12). Such a plan should apply four possible protective actions: evacuating, sheltering in place, using protective masks, and exhausting and purging, as already discussed in this chapter.

For protection against imperceptible agents, the only practical protective measures are those that are continuously in place, such as filtering all air brought into the building on a continuous basis and using automatic, real-time sensors that are capable of detecting the imperceptible agents.

CBR materials, as well as industrial agents, may travel in the air as a gas or on surfaces we physically contact. Dispersion methods may be as simple as placing a container in a heavily used area, opening a container, or using conventional (garden)/ commercial spray devices, or as elaborate as detonating an aerosol. **Most chemical warfare agents are gaseous, and biological and radiological agents are largely aerosols.**

Chemical incidents are characterized by the rapid onset (minutes to hours) of medical symptoms and easily observed indicators (e.g., colored residue, dead foliage, pungent odor, and dead animals, birds, fish, or insects; see Table 5-1 and Figure 5-4).

In the case of a biological incident, the onset of symptoms takes days to weeks and, typically, there will be no characteristic indicators (see Table 5-2 and Figure 5-5). Because of the delayed onset of symptoms in a biological incident, the area affected may be greater due to the migration of infected individuals.

In the case of a radiological incident, the onset of symptoms also takes days to weeks to occur and typically there will be no characteristic indicators (see Table 5-3 and Figure 5-6). Radiological materials are not recognizable by the senses because they are colorless and odorless.

Specialized equipment is required to determine the size of the affected area and if the level of radioactivity presents an immediate or long-term health hazard. Because of the delayed onset of symptoms in a radiological incident, the affected area may be greater due to the migration of contaminated individuals.

Table 5-1: Indicators of a Possible Chemical Incident

Dead animals, birds, fish	Not just an occasional roadkill, but numerous animals (wild and domestic, small and large), birds, and fish in the same area.
Lack of insect life	If normal insect activity (ground, air, and/or water) is missing, check the ground/water surface/shore line for dead insects. If near water, check for dead fish/aquatic birds.
Physical symptoms	Numerous individuals experiencing unexplained water-like blisters, wheals (like bee stings), pinpointed pupils, choking, respiratory ailments and/or rashes.
Mass casualties	Numerous individuals exhibiting unexplained serious health problems ranging from nausea to disorientation to difficulty in breathing to convulsions to death.
Definite pattern of casualties	Casualties distributed in a pattern that may be associated with possible agent dissemination methods.
Illness associated with confined geographic area	Lower attack rates for people working indoors than those working outdoors, and vice versa.

Table 5-1: Indicators of a Possible Chemical Incident (continued)

Unusual liquid droplets	Numerous surfaces exhibit oily droplets/film; numerous water surfaces have an oily film. (No recent rain.)
Areas that look different in appearance	Not just a patch of dead weeds, but trees, shrubs, bushes, food crops, and/or lawns that are dead, discolored, or withered. (No current drought.)
Unexplained odors	Smells may range from fruity to flowery to sharp/pungent to garlic/horseradish-like to bitter almonds/peach kernels to new mown hay. It is important to note that the particular odor is completely out of character with its surroundings.
Low-lying clouds	Low-lying cloud/fog-like condition that is not explained by its surroundings.
Unusual metal debris	Unexplained bomb/munitions-like material, especially if it contains a liquid. (No recent rain.)

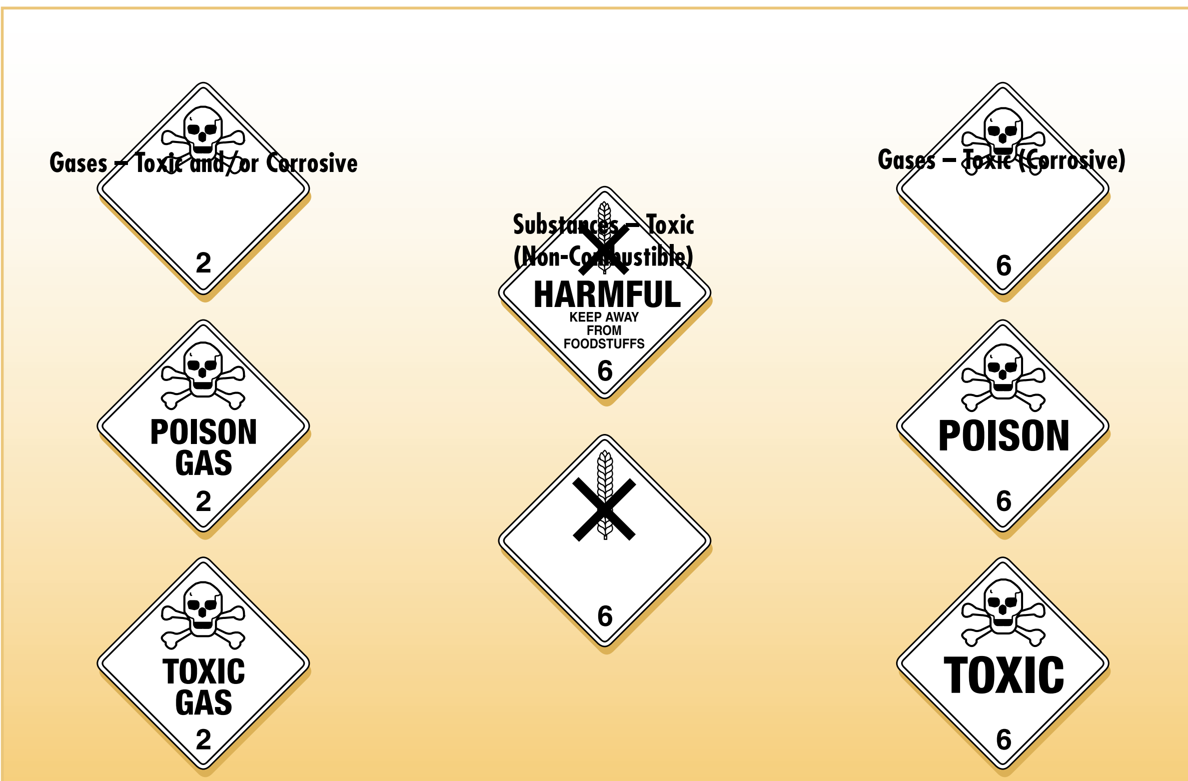


Figure 5-4 Placards associated with chemical incidents

Table 5-2: Indicators of a Possible Biological Incident

Unusual numbers of sick or dying people or animals	Any number of symptoms may occur. As a first responder, strong consideration should be given to calling local hospitals to see if additional causalities with similar symptoms have been observed. Casualties may occur hours to days or weeks after an incident has occurred. The time required before symptoms are observed is dependent on the biological agent used and the dose received. Additional symptoms likely to occur include unexplained gastrointestinal illnesses and upper respiratory problems similar to flu/colds.
Unscheduled and unusual spray being disseminated	Especially if outdoors during periods of darkness.
Abandoned spray devices	Devices will have no distinct odors.

Figure 5-5 Placards associated with biological incidents

Table 5-3 Indicators of a Possible Radiological Incident

Unusual numbers of sick or dying people or animals	As a first responder, strong consideration should be given to calling local hospitals to see if additional casualties with similar symptoms have been observed. Casualties may occur hours to days or weeks after an incident has occurred. The time required before symptoms are observed is dependent on the radioactive material used and the dose received. Additional symptoms likely to occur include skin reddening and, in severe cases, vomiting.
Unusual metal debris	Unexplained bomb/munitions-like material.
Radiation symbols	Containers may display a radiation symbol.
Heat emitting material	Material that seems to emit heat without any sign of an external heating source.
Glowing material/particles	If the material is strongly radioactive, it may emit a radioluminescence.

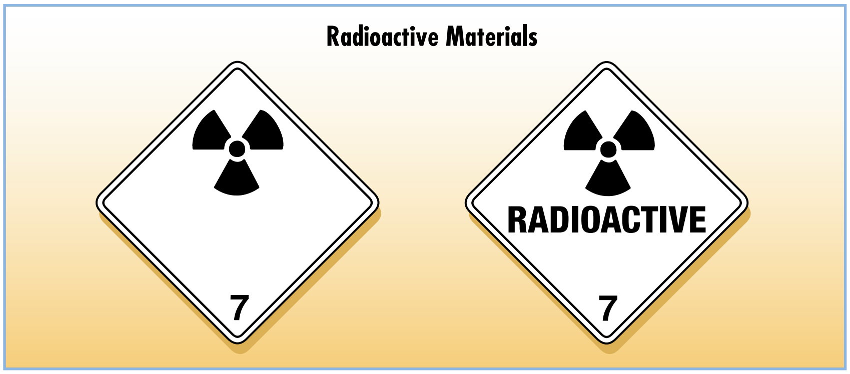


Figure 5-6 Placards associated with radiological incidents

SAFE ROOMS WITHIN SCHOOLS 6

This chapter is a work in progress and will be superceded by a future FEMA publication (FEMA 442) that will have expanded guidance on the subject of safe rooms. It is intended as a standalone description of the concept of safe rooms within schools that will resist CBR and blast threats and to provide school board members and decision-makers with the basic components of a protective system.

It is important to note that the probability of either a CBR or terrorist explosive event occurring in the United States is small. This is evidenced by the relatively few domestic buildings that have been targeted by intentional CBR or explosive events compared to the vast number of buildings that might be considered vulnerable. To date, two incidents of biological terrorism have been recorded and acknowledged to have had significant impacts on coincident populations in the United States: the 2001 anthrax mailings and the 1984 contamination of restaurants with Salmonella bacteria. If a localized CBR event were to occur, the potential for contamination to spread and cause collateral illnesses and fatalities up to 4 or more kilometers (approximately 2½ miles) from the target site would be likely. Unpredictable meteorological conditions would play a key role in the spread of such CBR contamination. Similarly, if an explosive event were to occur, there would be a significant potential for injuries resulting from debris impact and structural collapse. Therefore, in consideration of the proximity of some schools with respect to higher profile potential targets in the United States, school board members and administrators may determine that their select facilities require the design and construction of safe rooms. Because there are so many different types of school buildings, with so many different types of construction and materials, it is not possible to relate all the following issues to specific building types; nevertheless, an attempt was made to relate the relevant threats and the general principles of protective design to the development of safe rooms within schools.

This chapter discusses:

- The different types of hazards
- The general means by which these hazards might be addressed
- The protective methods that may be effective
- The level of effectiveness that may be achieved
- The information from which decision-makers can estimate the cost for providing different levels of protection

6.1 TYPES OF CBR HAZARDS

Chemical contaminants of concern are the chemical warfare agents (CWAs) and toxic industrial chemicals (TICs). Key attributes of CWAs and TICs are their toxicity, volatility, and availability. The most toxic CWAs are the nerve agent liquids, which include VX with high toxicity and low volatility, and Sarin with high toxicity and moderate volatility. The measured volatility of a chemical represents the ease with which the quantity of liquid chemical leaves the liquid state and becomes a gas in equilibrium with its volumetric surroundings. So, an occupant of a room where Sarin liquid is naturally evaporating is at much greater risk than the same individual being in the same room with the same or (to a degree greater) quantity of a naturally evaporating VX agent (see Appendix C). The lethality of VX exceeds the lethality of Sarin by dose, but Sarin is much more volatile than VX.

> A ranking of 49 TICs with regard to their threat when used against buildings applies three factors (availability, toxicity, and delivery system) on a scale of 1 to 5, with the highest number indicating the greatest hazard. About half of the TICs considered "threat agents" are gases at standard conditions and must be transported in pressurized cylinders. The military copper-silver-zinc-molybdenum-triethylenediamine (ASZM-TEDA) carbon is effective in filtering 22 of these 49 TICs, has marginal performance against 9 TICs, and poor performance against 18 TICs. The military ASZM-TEDA carbon is a special sub-grade of bound with pitch-low (BPL) activated carbon, impregnated with salts of copper, silver, zinc, and molybdenum, and with triethylenediamine (TEDA) to enhance the carbons adsorption characteristics.

6.1.1 Toxic Industrial Chemicals

Though of lower toxicity than nerve agents, TICs are widely available, and some can be easily obtained or produced without sophisticated equipment. Among the hundreds of TICs produced worldwide are several that have been used as CWAs (e.g., arsine, chlorine, hydrogen cyanide, phosgene, hydrogen sulfide, acrolein, and cyanogen chloride). Those that have been used in warfare are considered second-rate CWAs because their toxicity and vapor pressure make them less effective than other agents for open-air battlefield use.

6.1.2 Incapacitating and Tear-producing Agents

Although incapacitating and tear-producing agents are considered non-lethal, indoor releases can, under certain conditions, produce lethal concentrations. In addition to the tear-producing agents, there are commercially available agents containing oleoresin capsicum (OC), the natural oil of chili peppers. The malicious or accidental release of pepper spray has caused many disruptive incidents in recent years. In contact with the eyes, nose, or mouth, OC causes immediate pain and inflammation. Inhaled, its aerosol causes choking and gasping for breath. Of low vapor pressure, OC is easily filtered.

6.1.3 Biological Agents

Biological agents include bacteria, viruses, and rickettsia. Toxins, which are poisons of biological origin and not living organisms, are sometimes grouped with biological agents and sometimes with chemical agents. Although there are hundreds of microorganisms that could be used as biological agents, the likely number is much smaller when the agents' effectiveness, reliability, availability, ease of manufacture, and stability in storage and dissemination are considered. When disseminated as aerosols, biological agents are most effective in the size range of 1 to 5 microns, because they can remain suspended for long periods. Smaller particles are less likely to survive as aerosols, and larger particles settle rapidly, making them less likely to enter the

> HEPA filters were developed during World War II by the Atomic Energy Commission to remove radioactive dust particles from research spaces. Today, HEPA filters are used for various applications, including nuclear contamination, asbestos abatement, surgical facilities, tuberculosis wards, clean rooms, computer rooms, and other critical areas. A HEPA filter is 99.97 percent efficient in capturing particles 0.3 micron in diameter. HEPA filters are top of the line particulate filters. Although they are very good at filtering particles, they are also expensive to operate because they cause large drops in pressure. Therefore, they are generally only used in "high end" applications such as those mentioned above. HEPA filters are standard components with high-efficiency gas adsorber (HEGA) systems. These military adsorbers cost approximately $4.50 per cubic feet per minute (cfm), and their expected service life is 3 years, although service life varies with the air quality of the region and the moisture to which the filters are exposed over time. Use of only HEPA filters in a makeup-air unit would provide a high level of protection from biological agents, radiological agents, solid aerosols such as tear gas, and liquid aerosols of low vapor pressure.

lungs. The settling time in still air for an anthrax spore (1 micron by 0.7 micron in size) is approximately ½ foot per hour. Particles of this size are readily filtered from an air stream with high-efficiency particulate air (HEPA) filters. Toxins, which may be in crystalline or liquid form, are also filterable with HEPA when disseminated as aerosols.

6.1.4 Radiological Agents

Radiological agents are radioactive materials. Explosive release is the most likely means of disseminating such agents in a terrorist attack (e.g., a "dirty bomb" consisting of radioactive material packaged with a conventional explosive). The likely radioactive ingredients are those used for industrial and medical purposes (e.g., isotopes of cesium, cobalt, and iridium). They are commonly found in hospitals and labs, often with few safeguards. Given the availability of nuclear reactors for research or energy production by universities, research facilities, or private industries, the threat associated with radiological materials is significant. Radiological contaminants are very persistent, in that their decay rate is extremely slow. Unlike chemical or biological agents, decontamination involves only removal, not neutralization. Radiological aerosols present a health hazard if ingested or inhaled, but are easily filtered from an air stream with HEPA filters.

6.2 MOST LIKELY DELIVERY METHODS FOR CBR AGENTS

For purpose of vulnerability assessments, delivery methods are divided into four types of releases: internal, external proximate, remote, and remote with forewarning.

6.2.1 Internal Release

This involves transporting a container of agent into a building and releasing the contents manually, automatically, or remotely. Such a device may rely simply upon natural evaporation (as in the Tokyo subway Sarin attack), with the rate of evaporation proportional to the surface area that develops as liquid agent spills from its container. Aerosolization may occur with movement of an open package or letter containing a biological agent. A sprayer powered by batteries or compressed air can produce an effective dose of an agent quite rapidly. An agent can be released in any area served by return ducts/plenums or in a mechanical room, with dissemination through an air-handling unit. Biological agents can also be placed into certain types of humidifier systems.

6.2.2 External Proximate Release

This involves introducing an agent or a dissemination device from outside the building directly through a penetration in the building shell, such as a fresh-air intake. Vulnerability to this type of release is highest when air intakes are at accessible, unsecured locations at ground level. Agents can also be delivered through other penetrations, but potential effectiveness is less in the absence of a driving force (a fan) to introduce and distribute air within the building. A documented example of an attack through a ground-level penetration is the release of a toxic industrial gas from a pressurized cylinder through a dryer vent. External proximate release also includes forcing open or breaking windows and doors to introduce agents from pressurized cylinders or tossing a grenade or container of an agent into the building.

6.2.3 Remote Release

If directed at a specific facility, this type of attack involves a plume, puff, or line source generated so that the wind carries the agent to the target building; the facility may be the target or collaterally in the direction of the attack. The most efficient type of remote attack is a directed-plume attack with a ground-level source placed upwind of a building's fresh-air intakes or open windows. A ground-level, directed-plume attack was conducted with the nerve agent Sarin from a distance of 60 yards in Matsumoto, Japan, in 1994, killing 7 and injuring 264 in a zone 500 yards deep and 100 yards wide. A remote attack can also involve an aerial release. Release from an aircraft is much less likely to affect a specific, targeted building, however, because the vertical rate of transport, governed by settling time and atmospheric stability, is extremely difficult to judge.

6.2.4 Remote Release with Forewarning

This type of attack differs from other remote releases because protective actions other than those for no-warning attacks can be applied. This type involves warning in the form of an explosion or an event such as an accidental or intentional release of an agent from a chemical transport or storage tank. Scenarios involving forewarning include sabotage of toxic industrial storage tanks/trucks, transport accidents, fires, or the impending release of a chemical agent from a point upwind of the building. Quantities of agent that could be released from a single 3,000-gallon tanker truck are approximately 34,000 pounds for phosgene, 35,000 pounds for chlorine, and 17,000 pounds for hydrogen cyanide.

Scenarios

Aside from the recent attacks with mail-delivered anthrax of the past year, no CBR terrorist attacks have occurred on U.S. Federal Government facilities; therefore, based on precedence, the probability of such attacks is very low. Without intelligence information indicating that a specific group or person possesses plans, knowledge, resources, and motivation to carry out a CBR attack, the likelihood of such an attack can be estimated only by factors unrelated to specific groups. These factors relate to the target, environmental conditions, and difficulty of attack. Target factors include the value or symbolism of the target, recognizability, and appearance of vulnerability. Factors that relate to the difficulty of attack and conditions are: availability of the agent, complexity of the delivery method/system, effect of weather, standoff distance, and deterrence (risk to the attacker, likelihood of being observed/thwarted).

There is no justification on the basis of precedence to identify a school as a probable target for a direct terrorist attack. However, a school may be located in the vicinity of other U.S. government buildings or other iconic properties that may be more recognizable and of greater perceived target value. The more likely scenario for such schools, therefore, is one of collateral effects resulting from a remote release. General scenarios for remote release are presented below, followed by internal/proximate scenarios that would involve directly targeting a building.

6.3 VULNERABILITY TO REMOTE CBR RELEASE

In the absence of a secure perimeter around the building (see Section 2.4) and a real-time detection system, vulnerability to a remote release is determined by: 1) the efficiency of the school building's filtration system in removing aerosols and gases, 2) the unfiltered component of air exchange, and 3) the configuration of the school building and elevation of air intakes. These vulnerabilities can be characterized as follows.

> Against an external hazard, the level of protection provided by a school building with a filtration system is defined in terms of protection factor (i.e., the dose [concentration integrated over time] of an agent outside divided by the resulting dose of agent inside). If all makeup air passes through filters, the protection factor equals the inverse of the penetration factor of the filter (1 minus the filter removal efficiency).

- **Efficiency of gas filtration.** Generally, if adsorbers are found in buildings, they are for the purpose of improving indoor air quality by removing both outdoor and indoor air pollutants, particularly corrosive gases such as sulfur dioxide, nitrogen dioxide, and ozone, and are used where appropriate for protecting against the deleterious effects of these gases. Although not intended for protecting people from toxic chemical agents, these gas adsorbers do reduce the vulnerability to an attack with certain chemical agents.

  With a 1-inch bed thickness of coarse (4x6 mesh) sorbent granules and a short residence time of these indoor air quality filters, the efficiency is about 99 percent initially, and it diminishes with time in service, typically to about 25 percent in a year. There is also an initial bypass of roughly 1 percent through the bed and additional bypasses among filter modules' holding frames. The bypasses may increase with time in service, dropping the net efficiency below the initial level. This compares with an efficiency of greater than 99.999 percent for gas adsorbers designed for protection of people in military applications. Removal efficiency for these indoor air quality adsorbers is relatively low and uncertain for some of the threat agents (the capacity for arsine is low, for example). Thus, the efficiency and capacity are highly variable. Manufacturers provide surveillance testing to determine when to change filters and recommend that they be changed when reactive capacity has dropped to 25 percent of the initial value. The typical service life for single stage, 1-inch beds is approximately 1 year.

- **Particulate filtration.** Significant particulate filtration can be accomplished by using a 35-percent pre-filter and a 95-percent filter in series. The efficiency of this filter train is in the range of 95 to 99 percent for 1-micron particles in the new condition, and this efficiency increases as the filters load.

- **Unfiltered air exchange.** Typical of schools, a substantial portion of the air exchanged between indoors and outdoors may not pass through the filters of any air-handling units. When this occurs, the level of protection the building structure provides is, therefore, governed not by the efficiency of the filters but rather by that portion of makeup air bypassing the filters. There are several paths by which air exchange is driven by fans, buoyancy, and/or wind pressures. They include operable windows; doorways with flows driven by buoyancy, particularly in summer and winter when indoor-outdoor temperature differentials are highest; and unintentional openings in the building shell. When internal resistance is minimal, less dense (buoyant) warm air rises and flows out of a school building near its top in winter, drawing in cool air at the lower levels. Conversely, in summer, cool air falls and flows out of the building's base. The buoyancy effect tends to be less pronounced in spring and fall because of smaller indoor and outdoor temperature differences. With the standard draw-through configuration of the air-handling units, leakage paths at the access doors and panels are subject to inward pressure; these leakage paths increase as the gaskets age. Typically, access doors also fail to seal well with filter frames, allowing bypass that increases with age.

- **Typical protection factors achievable**. In terms of protection factor, protection against aerosols (biological/radiological agents and others such as tear gas) provided by the best (standard) filtration systems available in air-handling units is substantial, but relatively low (in the range of approximately 5 to 50). Protection factor is a ratio of dose (concentration integrated over time) of an agent outside divided by the resulting dose of agent inside a building). This level of protection is comparable to that achievable with sheltering in place or an active detection-based system that responds by de-energizing fans and closing dampers. The higher value in this range is estimated by taking the inverse of the penetration factor for 1-micron particles through the filters, including an initial bypass of approximately 1 percent. The lower value in the protection-factor range is estimated for both particulate and gas filters by using 20 percent as an estimate of the unfiltered air exchange; the inverse of the penetration factor (0.2) is 5.

With an indoor air quality filter unit having a gas adsorber, the protection factor for gases can be as high as 50, but only when filters are new and only with gas adsorbers. The protection drops to a low value as the filter efficiency decreases with time in service. This may be less than 2 if the efficiency drops below 50 percent after 1 year in service. The protection factor against gases is also reduced by the portion of outside air (which could be at least 80 percent) that does not flow through gas adsorbers. With a penetration of 80 percent, the protection factor for gases for the whole building is less than 2.

Summary: Vulnerability to Remote Release

A typical building would have high vulnerability to a remote release of aerosols (biological and radiological agents) and a high vulnerability to a remote release of gases (chemical agents). The basis for this rating is:

- Estimated protection factors are in the range of 5 to 50 for aerosols, based on a substantial volume of unfiltered air exchange.
- Use of gas adsorbers is atypical of building air-handling ventilation systems.
- Outside air intakes in building construction are often located near ground level, making them especially vulnerable.

Vulnerability can be reduced by:

- Application of gas adsorbers to all air-handling units
- Employing particulate filters of higher efficiency (e.g., 95 percent) and low bypass

6.4 VULNERABILITY TO REMOTE CBR RELEASE WITH FOREWARNING

This type of attack involves release of agent by explosion or rapid release from a tanker truck, rail car, or fixed storage tank. The potential for this type of attack is higher when the facility is near rail lines, public roads with truck traffic, or storage tanks of toxic chemicals. This type of attack may also involve an explosive release of a radiological agent (i.e., a "dirty bomb" attack at a distance from the building great enough to allow for protective actions to be taken before wind carries the agent to the building).

The criterion for this aspect of vulnerability is the ability to rapidly assume a sheltering-in-place posture (see Section 5.2). The main requirements are plans/procedures for sheltering, controls to rapidly turn off all fans, and a communications or public address system to facilitate closing of doors and keeping them closed while an outdoor hazard is present or imminent. Protection factors vary, diminishing with time of exposure; however, scenarios of explosive release under most conditions would present a relatively short exposure to the school building.

Summary: Vulnerability to Remote CBR Release With Forewarning

A typical school building would have high vulnerability to a remote release with forewarning. The basis for this rating is:

- Schools should develop plans/procedures for sheltering and rapid deactivation of all fans and closing of doors and windows.
- Schools have limited filtration capabilities for gases and aerosols; therefore, the vulnerability to a remote release with forewarning is aproximately the same as the vulnerability to a remote release without forewarning.

Vulnerability can be reduced by:

- Developing an emergency plan for sheltering in place that includes rapidly de-energizing all fans and closing doors and windows.

6.5 VULNERABILITY TO INTERNAL CBR RELEASE

This is a remote possibility owing to the nature and likelihood of other vandalism and that actual targeting of a school has no historical precedence. Nevertheless, internal releases involve covert entry or covert introduction of agents in containers. Vulnerability to internal release is, therefore, determined principally by physical security measures in place. Containers of agents may be hand-carried or delivered in mail, supplies, or equipment. Other factors affecting this vulnerability are internal (recirculation) filtration and how well entry zones where any screening takes place are isolated architecturally and mechanically.

The basis for preventing covert introduction of agents is access control and entry screening. Use of the X-ray machine for hand-carried items facilitates the detection of containers large enough to hold hazardous quantities of chemical agents; however, it requires specific operating procedures for doing so, and it may not be effective in detecting containers of hazardous quantities of biological agents. Obviously, such procedures are not recommended for schools without provocation (i.e., an actual threat) because of cost.

6.6 VULNERABILITY TO EXTERNAL PROXIMATE CBR RELEASE

Vulnerability to external proximate release is determined mainly by the accessibility of outside air intakes to covert introduction of agent or agent-dissemination device. Unless air intakes are relocated at a higher elevation, this vulnerability would remain high.

The three strategies for protecting a school building from airborne hazards originating outdoors are air filtration, controlling air exchange, and exclusion by physical security. Options presented in this chapter focus on air filtration; however, enhanced filtration techniques discussed earlier would be applied most economically in schools to a selected safe room, such as a school gymnasium or auditorium. Without a secure exclusion zone around the school building, physical security measures are limited to those described above for external proximate release and internal release.

Controlling air exchange is most commonly employed with human detection and warning (i.e., sheltering in place). It can also be applied with automatic, real-time detection equipment, but with very limited effectiveness. Few agents among the full spectrum of threat agents can be detected with accuracy in real time. Protection factors vary with response time and, even with instantaneous response, protection factors are no greater than the maximum protection factors achievable with sheltering in place. As the response time increases, protection factors diminish. With current technology, response times are longest for biological agent detection. The response time for presumptive identification by a detector such as the Joint Biological Point Detection System is approximately 30 minutes and far exceeds the response time needed for effective use of sheltering in place. A biological detection system would not, therefore, prevent the contamination of a particular building.

- **Criteria for protective performance.** All of the following discussion represents extreme measures applied to high-risk, high-security assets or, in general, to lesser degrees, safe rooms, and perhaps to would-be safe rooms for schools. There is no standard requirement for protection factors. U.S. military systems are designed to achieve protection factors greater than 10,000. The criterion applied to military masks and collective protection shelters is 6,667, which is based upon specific levels for chemical agents on the battlefield and for threshold effects of the chemical agents on soldiers. There is no criterion for biological or radiological agents based upon concentrations and doses likely to be developed in an attack on a school building; however, it would be 10,000 or greater.

To increase the protection factors to 10,000 or higher for selected envelopes requires: 1) high-efficiency filters (HEPA and HEGA) with leak-tight seals at the holding frames; 2) pressurization of the protective envelope; 3) pressurization of mechanical rooms in which air-handling units are located and return ducts not within the protective envelope; 4) adding vestibules/airlocks at entrances to protected zones where entry/exit is frequent; and 5) permanently closing windows.

The selection of a CBR safe room in a school building requires an assessment of factors contributing to infiltration (or wind penetration from the outside). To prevent infiltration through the protected envelope requires an internal pressure of approximately 50 Pascals [0.2 inch, water gauge (iwg)]. This pressure does not prevent infiltration driven by buoyancy and wind pressures under all possible conditions, but it does so under wind conditions most conducive to a (stand-off) plume attack (see Table 6-1). The level of safe room pressurization should exceed 95-99 percent of the meteorological conditions for the given school location. Note that wind does not exert a uniform pressure on a building face; the pressure varies by location on the building face and the angle of incidence. A 20 mile-per-hour (mph) wind velocity is not uncommon in the United States and, thus, a safe room pressurized to 50 Pascals would prevent infiltration from time averaged 20 mph winds.

Table 6-1: Pressures Exerted on a School Building Face by Wind

Wind Velocity* [mph]	From [Pascal]	To [Pascal]
2	0.2	0.4
4	1.0	1.7
6	2.2	3.9
8	3.9	6.9
10	6.0	10.8
15	13.5	24.4
20	24.1	43.3
25	37.6	67.7

*Time Averaged and Normal (90%) Incidence to School Building Face

There are several options for improving protection factors with filtration; they involve both the type/configuration of the filter system and the extent of the protective envelope.

- **Options for type of filter system.** Four options for a dedicated type of filtration system for a safe room include:

  - **Improving mixed-air particulate filtration of air-handling units.** Particulate filters may be upgraded to 95-percent filters, providing the potential for substantial improvement in protection against biological agent aerosols. The limit of protection factor against 1-micron particles, however, is approximately 100 with pressurization of the protective envelope and reduction of bypass at the filter frames. Reduction of bypass requires sealing and gasketing existing retainers, slide-in tracks, and access doors, and adding gaskets between filter frames in slide-in tracks. Pressurization can be achieved by rebalancing the air-handling units and controlling the flows through open doorways and windows. Among the options for improvement are to upgrade the filters to HEPA with leak-tight holding frames; with pressurization, this would increase the potential protection factor to about 10,000 for biological agents, but not for chemical agents. This option requires special holding fixtures for the filters and may require replacement of supply fans to accommodate higher pressure drop.

  - **Improving mixed-air gas filtration of the air-handling units.** An option to increase protection factors of a school building for chemical agents is to install gas adsorbers in air-handling units. This would involve adding the indoor air quality (IAQ) type adsorbers to existing air-handling units, at a cost of $0.50 per cfm. With a 1-year service life, the filter replacement costs would be $0.25 per cfm. Additional energy related operating costs would be incurred due to the pressure drop of the adsorbers (0.75 iwg). This option does not provide high efficiency against all chemical agents.

  - **Installing makeup-air units with HEGA and HEPA filters.** A makeup air unit for both gases and aerosols includes the following components in series: pre-filter, fan, HEPA filter, HEGA filter, and heating and cooling coils. The makeup-air unit provides filtered outside air to pressurize the protective envelope. It eliminates recirculation and the internally induced infiltration associated with applying a single fan for both makeup air and recirculated air. The most cost-effective HEGA filter units currently available for protection from chemical agents employ the military-standard 200-cfm radial-flow filters per MIL-PRF-51527A, “Filter Set, Gas-particulate, 200 cfm," Type II. These contain ASZM-TEDA carbon of 12x30 mesh size in 2-inch-deep beds, which removes all chemical warfare agents and a substantial number of toxic industrial chemicals. These provide removal efficiency greater than 99.999 percent throughout their service life (estimated at 3 years). HEPA filters are standard components with HEGA systems. These military adsorbers cost approximately $4.50 per cfm, and their expected service life is 3 years, although service life varies with the air quality of the region and the moisture to which the filters are exposed over time. Maintenance costs run approximately $2 per year per cfm. Maintenance also includes changing HEPA filters annually and pre-filters every 90 days. With total pressure drop of 6 iwg across the adsorber and HEPA filter, energy costs for the high-efficiency filtration run approximately $0.50 per cfm per year.

- **Installing makeup-air units with HEPA only.** Use of only HEPA in a makeup-air unit would provide a high level of protection from biological agents, radiological agents, solid aerosols such as tear gas, and liquid aerosols of low vapor pressure. High-level protection against biological aerosols is particularly beneficial because there is no capability for real-time detection of biological agents (all strategies that require biological detection are mitigation strategies involving decontamination and medical treatment). Use of HEPA only in a makeup-air unit would substantially reduce hardware costs, maintenance costs, and electrical costs of ventilation as well as the space requirements for the units. Protection at a lower level would still be provided by filtration of recirculated air with gas adsorbers in air-handling units.

6.7 RECOMMENDATIONS FOR CBR PROTECTION

The following actions are recommended for CBR protection:

- To provide a substantial level of protection against an external release of CBR agents, apply any one of the filtration options summarized above to a renovated school gymnasium or auditorium safe room.

- To protect against a remote attack with a chemical or radiological agent, plans, procedures, and training for sheltering in place should be developed. To support this protective measure, a rapid notification system (public address system) and controls for rapid deactivation of fans and closing of dampers should be defined. A guide for developing protective action plans is available in the Army Corps of Engineers draft Technical Instruction TI 853-01 *Protecting Buildings and Their Occupants from Airborne Hazards*, dated October 2001.

- To reduce vulnerability to internal release, implement security procedures specific to entry screening for containers of unknown liquids or gases being carried into the secure area. Provide training to employees on awareness of the CBR threat and the protective action plan.

6.8 SAFE ROOMS IN RESPONSE TO THE DOMESTIC EXPLOSIVE THREAT

The concept of safe rooms has been around for quite some time. Bomb shelters were used in the United Kingdom (U.K.) during World War II to protect the civilian populations against aerial attack and fall-out shelters were established in cities in the United States during the Cold War to protect against the lingering effects of a feared nuclear attack. More recently, the Israeli Defense Force (IDF) requires apartment protected spaces (APSs) or floor protected spaces (FPSs) to be constructed in every new building or to be added to existing buildings according to engineering specifications. In buildings in which no shelters exist, interior rooms may be converted to shelters by following IDF instructions. In all cases, the shelters must be accessible within 2 minutes of a warning siren. The protected spaces are intended to serve as a refuge when an attack is suspected, either through early warning or remote detection; however, the protected space is much less effective when the event takes place without warning. Two minutes and eleven seconds elapsed between the time the Ryder truck stopped in front of the Murrah Federal Building in Oklahoma City and the detonation of its explosives, but no one was alerted to the danger until the explosion occurred.[1] At Khobar Towers in Dhahran, Saudi Arabia, U.S. Air Force Security Police observers on the roof of the building overlooking the perimeter identified the attack in progress and alerted many occupants to the threat; however, evacuation was incomplete and 500 people were wounded and 19 people were killed by the explosion.[2]

The effectiveness of the safe room in protecting occupants from the effects of an explosive detonation is, therefore. highly dependent on early detection and warning. Unless the attacker notifies authorities of a bomb threat, as often occurred in the terrorist activities in Northern Ireland, the safe room can best be used after an explosion occurs in anticipation of a second attack. The 1998 bombing of the U.S. Embassy in Kenya was preceded by a small explosion that drew curious embassy employees to the windows; such a tactic, if repeated in the United States, would justify the relocation of school occupants to a safe room until school officials are able to determined that it is safe to disperse the students. To these limited objectives, the establishment of a safe room in schools may serve a useful purpose. Given the nature of the explosive threat, however, it may be more effective to provide debris mitigating protective measures for all exterior façade elements.

It is important to understand the nature of the domestic explosive threat in order to effectively plan for the protection of different

[1] The structural features of the building, including the transfer girders that spanned over the main entrances, along with the relatively short distance from the curb to the face of the building, were the most significant contributing factors to the collapse.

[2] Although the precast structure was subjected to overwhelming blast loads, which blew the front façade into the occupied spaces, the building was designed to the U.K. regulations, which have provisions for structural robustness that require precast components to be tied together.

types of facilities and particularly for the establishment of safe rooms in schools. Although the patterns of past events may not predict the future, they give valuable insight to the protection against a very low probability, but potentially high consequence event. As previously discussed, despite a wide range of terrorist events, such as CBR contamination, an explosion remains the most insidious threat, requiring the least sophisticated materials and expertise. The principal components of an explosive device can be obtained at a variety of retail outlets, without arousing suspicion. Every year, over 1,000 intentional explosive detonations are reported by the FBI Bomb Data Center. In 1998, the last year for which the compiled data were published, there were 1,225 actual incidents of unauthorized explosions in the United States.[3] The majority of these explosives were targeted against residential properties and vehicles; however, 76 explosive events were detonated at educational facilities, causing a total of $28,500 in property damage.[4] In addition to these actual events, 63 incidents involving hoax devices were investigated. By contrast, only one explosive device was detonated at a Federal Government facility, causing $1.5 million in property damage, and eight were detonated at local/state government facilities, causing $316,000 in property damage. Over 70 percent of the people involved in bombing incidents were "young offenders" and less than ½ percent were members of terrorist groups. Vandalism was the motivation in 40 percent of the intentional and accidental bombing incidents. Although two out of three attacks were perpetrated between 6 p.m. and 6 a.m., the incidents against educational facilities were more uniformly distributed throughout the day. Although each successive major domestic terrorist event exceeded the intensity of

Types of Explosive Threats

As explained in Chapter 4, the effects of an explosion primarily depend on the weight of the explosives, the type of the explosives, and the distance from the point of detonation to the protected structure. Different types of explosive materials are classified as high energy and low energy, and these different classifications greatly influence the damage potential of the detonation. High energy explosives, which efficiently convert the material's chemical energy into blast pressure, represent less than 1 percent of all explosive detonations reported by the FBI Bomb Data Center. The vast majority of the incidents involve low energy devices in which a significant portion of the explosive material is consumed by deflagration. In these cases, a large portion of the material's chemical energy is dissipated as thermal energy, which may cause fires or thermal radiation damage.

[3] U.S. Department of Justice, Federal Bureau of Investigation, General Information Bulletin 98-1.

[4] The Bomb Data Center information does not indicate whether any of these events were preceded by a warning nor does it indicate the average weight of explosives used.

the predecessor, this is not particularly relevant to the threats to which a school structure might be subjected; if an explosive were to be detonated in or around a school building, it would most likely be a small improvised device assembled by a youth and vandalism is most likely to be the motive.

The size of the explosive that might be considered for a protective design is limited by the maximum weight that might be transported either by hand or by vehicle (for additional information, see Section 4.2). Despite the large weight of explosives that might be transported by vehicle, there have been relatively few large-scale explosive events within the United States. The 1995 explosion that collapsed portions of the Murrah Federal Building in Oklahoma City contained 4,800 pounds of ammonium nitrate and fuel oil (ANFO) and the 1993 explosion within the parking garage beneath the World Trade Center complex contained 1,200 pounds of urea nitrate. As implied by the FBI statistics, the majority of the domestic events contain significantly smaller weights of low energy explosives. The explosive that was used in the 1996 pipe bomb attack at the Olympics in Atlanta consisted of smokeless powder and was preceded by a warning that was called in 23 minutes before the detonation. Nevertheless, the protective design of structures focuses on the effects of high energy explosives and relates the different mixtures to an equivalent weight of trinitrotoluene (TNT).

As discussed in Chapter 4, the distance of the protected structure from the point of explosive detonation is commonly referred to as the stand-off distance. As the front of the shock-wave propagates away from the source of the detonation at supersonic speed, it expands into increasingly larger volumes of air, the peak incident pressure at the shock front decreases, and the duration of the pressure pulse increases. The shock front first impinges on the leading surfaces of a structure located within its path and then engulfs the entire structure. Both the intensity of peak pressure and the impulse, which considers the effect of both pressure intensity and pulse duration, affect the hazard potential of the blast loading. Other issues, such as the geometry of the waves impacting the protected structure and the reflectivity of the surroundings, will either amplify or reduce the intensity of the blast loading.

6.9 LOCATING SAFE ROOMS TO MITIGATE THREATS

The building's façade is its first real defense against the effects of a bomb and typically the weakest component that would be subjected to blast pressures. Although the response of specific glazed components[5] is a function of the dimensions, make-up, and construction techniques, the conventionally glazed portions of the façade would shatter and inflict severe wounds when subjected to a 50-pound explosive detonation at a stand-off distance on the order of 200 feet. If the glazed elements are upgraded with a fragment retention film (FRF), the same façade element may be able to withstand a 50-pound explosive detonation at a stand-off distance on the order of 70 feet. Unreinforced masonry block walls are similarly vulnerable to collapse when subjected to a 50-pound threat at a stand-off distance of 50 feet; however, if these same walls are upgraded with a debris catching system, they may be able to sustain this same intensity explosive detonation at a stand-off distance on the order of 20 feet. If the weight of explosives were increased from 50 pounds to 500 pounds, the required stand-off distances to prevent severe wounds increases to 500 feet for conventional window glazing, 200 feet for window glazing treated with a FRF, 250 feet for unreinforced masonry block walls, and 60 feet for masonry walls upgraded with a debris catching system. Based on these dimensions, it is apparent that substantial stand-off distances are required for the unprotected structure and these distances may be significantly reduced through the use of debris mitigating retrofit systems. Furthermore, because blast loads diminish with distance and geometry of wave propagation relative to the loaded surface of the building, the larger threats at larger stand-off distances are likely to damage a larger percentage of façade elements than the more localized effects of smaller threats at shorter stand-off distances. Safe rooms that may be located within the school should, therefore, be located in windowless spaces or spaces in which the window glazing was upgraded with a FRF.

[5] Glazing refers to the glass make-up, either single pane or insulated double pane, that is used in a window system.

Vulnerability to Domestic Explosive Threat

Throughout this primer, recommendations have been provided for schools that may be considered to be at high risk with the sound knowledge that schools are not currently considered to be at risk from potential terrorist attacks. However, it is important to note that proximity of a building to a high valued or iconic facility or its proximity to an industrial facility containing volatile chemicals may influence a structure's risk to blast damage. In particular, if a school is located in close proximity to a U.S. courthouse, federal office building, or major financial institution, it may suffer collateral damage in the event the high-risk structure is the target of an explosive event. Similarly, if the school is located in close proximity to a grain elevator or industrial plant handling explosive materials, it may suffer collateral damage in the event of an accidental explosion. Although the increased vulnerability is a function of the stand-off distance and weight of explosive, large quantities of glass may fail in response to the detonation of a vehicle bomb. The risk to the protected structure is, therefore, a function of the risk of its being the intended target of an attack and the risk of being in close proximity to another structure that is the intended target of an attack. Schools in rural and suburban sites are typically sited on large parcels of land and surrounded by athletic fields and parking lots. This increases the stand-off distance from publicly traveled roadways. Schools in urban sites may be located in close proximity to prominent structures that are more likely to receive explosive threats and the stand-off distances to these threat locations may be sufficiently small to place the school building in jeopardy of significant collateral damage. School buildings that were located within several blocks of the World Trade Center were affected by the terrorist events. Urban school buildings should be evaluated on a case by case basis to determine their vulnerabilities and risks.

The history of domestic explosive events doesn't justify the inspection of hand carried parcels into school buildings. Although metal detection and parcel searches are implemented within problem districts, these are primarily for other types of weapons or controlled substances. However, if an explosive device were to be carried into a school and detonated within the building, the resulting pressures would be confined and the effects of the explosion would be amplified. The blast waves and subsequent gas pressures would seek the path of least resistance as it seeks to equilibrate with the undisturbed atmosphere. Although the pipe or parcel bomb is small compared to the weights of explosives that might be transported in a vehicle, it would inflict injuries to occupants in close proximity and within direct line of sight of the detonation or located behind conventional nonstructural partitions. At short stand-off distances, these explosives could damage soft tissue such as lungs and eardrums and, at larger stand-off distances, these explosives could create debris that would impact the occupants. If a suspicious package is located within the building, the occupants would most likely be evacuated through exits that would lead them away from the potential threat. If, however, the occupants must be moved to a safe room, this space must be surrounded by a substantial structural wall or a reinforced masonry wall to limit the extent of debris.

Although small weights of explosives are not likely to produce significant blast loads on the roof, low-rise structures may be vulnerable to blast loadings resulting from large weights of explosives at large stand-off distances that may sweep over the top of the building. The blast pressures that may be applied to these roofs are likely to far exceed the conventional design loads and, unless the roof is a concrete deck or concrete slab structure, it may be expected to fail. There is little that can be done to increase the roof's resistance to blast loading that doesn't require extensive renovation of the building structure. Therefore, safe rooms should be located at lower floors, away from the roof debris that may rain down in response to blast loading.

The building's lateral load resisting system, the structural frame or shear walls that resist wind and seismic loads, will be required to receive the blast loads that are applied to the exterior façade and transfer them to the building's foundation. This load path is typically through the floor slabs that act as diaphragms and interconnect the different lateral resisting elements. The lateral load resisting system for a school building depends, to a great extent, on the type of construction and region. In many cases, low-rise buildings do not receive substantial wind and seismic forces and, therefore, do not require substantial lateral load resisting systems. Because blast loads diminish with distance, a package sized explosive threat is likely to locally overwhelm the façade, thereby limiting the force that may be transferred to the lateral load resisting system. However, the intensity of the blast loads that may be applied to the building could exceed the design limits for most conventional school construction. As a result, the building is likely to be subjected to large inelastic deformations that may produce severe cracks to the structural and nonstructural partitions. There is little that can be done to upgrade the existing school structure to make it more flexible in response to a blast loading that doesn't require extensive renovation of the building. Safe rooms should, therefore, be located close to the interior shear walls or reinforced masonry walls in order to provide maximum structural support in response to these uncharacteristically large lateral loads.

In addition to the hazard of impact by façade debris propelled into the building or roof damage that may rain down, the occupants may also be vulnerable to much heavier debris resulting from structural damage. Progressive collapse occurs when an initiating localized failure causes adjoining members to be overloaded and fail, resulting in an extent of damage that is disproportionate to the originating region of localized failure. The initiating localized failure may result from a sufficiently sized parcel bomb that is in contact with a critical structural element or from a vehicle sized bomb that is located at a short distance from the structure. However, a large explosive device at a large stand-off distance is not likely to selectively cause a single structural member to fail; any damage that results from this scenario is more likely to be widespread and the ensuing collapse cannot be considered progressive. Although progressive collapse is not typically an issue for buildings three stories or shorter, transfer girders or precast construction may produce structural systems that are not tolerant of localized damage conditions. The columns that support transfer girders and the transfer girders themselves may be critical to the stability of a large area of floor space. Similarly, precast construction that relies on individual structural panels may not be sufficiently tied together to resist the localized damage or large structural deformations that may result from an explosive detonation. As a result, safe rooms should not be located on a structure that is either supported by or underneath a structure that is supported by transfer girders unless the building is evaluated by a licensed professional engineer. The connection details for multi-story precast structures should also be evaluated before the building is used to house a safe room.

Nonstructural building components (e.g., piping, ducts, lighting units, and conduits) that are located within safe rooms must be sufficiently tied back to a competent structure to prevent failure of the services and the hazard of falling debris. To mitigate the effects of in-structure shock that may result from the infilling of blast pressures through damaged windows, the nonstructural systems should be located below the raised floors or tied to the ceiling slabs with seismic restraints.

Safe rooms in existing school buildings should be selected to provide the space required to accommodate the school population; should be centrally located to allow quick access from any location within the building; should be enclosed with fragment mitigating partitions or façade; and should be within robust structural systems that will resist collapse. These large spaces are best located at the lower floors, away from a lightweight roof and exterior glazing elements. If such a space does not exist within the existing school structure, the available spaces may be upgraded to achieve as many of these attributes as possible. This will involve the treatment of the exterior façade with fragment mitigating films, blast curtains, debris catch systems, spray-on applications of elasto-polymers to unreinforced masonry walls, hardening of select columns and slabs with composite fiber wraps, and steel jackets or concrete encasements. Fragment mitigating and structural upgrades and recommendations for blast protection are discussed in the following sections.

6.10 FRAGMENT MITIGATING UPGRADES

The conversion of existing construction to provide blast-resistant protection requires upgrades to the most fragile or brittle elements enclosing the safe room. Failure of the glazed portion of the façade represents the greatest hazard to the occupants. Therefore, the exterior glazed elements of the school façade and, in particular, the glazed elements of the designated safe rooms, should be protected with a FRF, also commonly known as anti-shatter film (ASF), "shatter-resistant window film" (SRWF), or "security film." These materials consist of a laminate that will improve post-damage performance of existing windows. Applied to the interior face of glass, ASF holds the fragments of broken glass together in one sheet, thus reducing the projectile hazard of flying glass fragments. See FEMA 426 *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings* for more information.

Most ASFs are made from polyester-based materials and coated with adhesives. They are available as clear, with minimal effects to the optical characteristics of the glass, and tinted, which provide a variety of aesthetic and optical enhancements and can increase the effectiveness of existing heating/cooling systems. Most films are designed with solar inhibitors to screen out ultraviolet (UV) rays and are available treated with an abrasion resistant coating that can prolong the life of tempered glass.[6] However, over time, the UV absorption damages the film and degrades its effectiveness.

According to published reports, testing has shown that a 7-mil thick film, or specially manufactured 4-mil thick film, is the minimum thickness that is required to provide hazard mitigation from blast. Therefore, a 4-mil thick ASF should be utilized only if it has demonstrated, through explosive testing, that it is capable of providing the desired hazard level response.

The application of security film must, at a minimum, cover the clear area of the window. The clear area is defined as the portion of the glass unobstructed by the frame. This minimum applica-

[6] Abrasions on the faces of tempered glass reduce the glass strength.

tion, termed daylight installation, is commonly used for retrofitting windows. By this method, the film is applied to the exposed glass without any means of attachment or capture within the frame. Application of the film to the edge of the glass panel, thereby extending the film to cover the glass within the bite, is called an edge to edge installation and is often used in dry glazing installations. Other methods of retrofit application may improve the film performance, thereby reducing the hazard; however, these are typically more expensive to install, especially in a retrofit situation.

Although a film may be effective in keeping glass fragments together, it may not be particularly effective in retaining the glass in the frame. ASF is most effective when it is used with a blast tested anchorage system. Such a system prevents the failed glass from exiting the frame.

The wet glazed installation, a system where the film is positively attached to the frame, offers more protection than the daylight installation. This system of attaching the film to the frame reduces glass fragmentation entering the building. The wet glazing system utilizes a high strength liquid sealant, such as silicone, to attach the glazing system to the frame. This method is more costly than the daylight installation.

Securing the film to the frame with a mechanically connected anchorage system further reduces the likelihood of the glazing system exiting the frame. Mechanical attachment includes anchoring methods that employ screws and/or batten strips that anchor the film to the frame along two or four sides. The mechanical attachment method can be less aesthetically pleasing when compared to wet glazing because additional framework is necessary and is more expensive than the wet glazed installation.

Window framing systems and their anchorage must be capable of transferring the blast loads to the surrounding walls. Unless the frames and anchorages are competent, the effectiveness of the attached films will be limited. Similarly, the walls must be able to withstand the blast loads that are directly applied to them and accept the blast loads that are transferred by the windows. The strength of these walls may limit the effectiveness of the glazing upgrades.

If a major rehabilitation of the façade is required to improve the mechanical characteristics of the building envelope, a laminated glazing replacement is recommended. Laminated glass consists of two or more pieces of glass permanently bonded together by a tough plastic interlayer made of polyvinyl butyral (PVB) resin. After being sealed together, the glass "sandwich" behaves as a single unit. Annealed, heat strengthened, tempered glass, or polycarbonate glazing can be mixed and matched between layers of laminated glass in order to design the most effective lite for a given application. When fractured, fragments of laminated glass tend to adhere to the PVB interlayer, rather than falling free and potentially causing injury.

Laminated glass can be expected to last as long as ordinary glass provided it is not broken or damaged in any way. It is very important that laminated glass is correctly installed in order to ensure long life. Regardless of the degree of protection required from the window, laminated glass needs to be installed with adequate sealant to prevent water from coming in contact with the edges of the glass. A structural sealant will adhere the glazing to the frame and allow the PVB interlayer to develop its full membrane capacity. Similar to attached film upgrades, the window frames and anchorages must be capable of transferring the blast loads to the surrounding walls.

Blast curtains are made from a variety of materials, including a warp knit fabric or a polyethylene fiber. The fiber can be woven into a panel as thin as 0.029 inch that weighs less than 1.5 ounces per square foot. This fact dispels the myth that blast curtains are heavy sheets of lead that completely obstruct a window opening and eliminate all natural light from the interior of a protected building. The blast curtains are affixed to the interior frame of a window opening and essentially catch the glass fragments produced by a blast wave. The debris is then deposited on the floor at the base of the window. Therefore, the use of these curtains does not eliminate the possibility of glass fragments penetrating the interior of the occupied space, but instead limits the travel distance of the airborne debris. Overall, the hazard level to occupants is significantly reduced by the implementation of the blast curtains. However, a person sitting directly adjacent to a window outfitted with a blast curtain may still be injured by shards of glass in the event of an explosion.

The main components of any blast curtain system are the curtain itself, the attachment mechanism by which the curtain is affixed to the window frame, and either a trough or other retaining mechanism at the base of the window to hold the excess curtain material. The blast curtain with curtain rod attachment and sill trough differ largely from one manufacturer to the next. The curtain fabric, material properties, method of attachment, and manner in which they operate all vary, thereby providing many options within the overall classification of blast curtains. This fact makes blast curtains applicable in many situations.

Blast curtains differ from standard curtains in that they do not open and close in the typical manner. Although blast curtains are intended to remain in a closed position at all times, they may be pulled away from the window to allow for cleaning, blind or shade operation, or occupant egress in the case of fire. However, the curtains can be rendered ineffective if installed such that easy access would provide opportunity for occupants to defeat their operation. The color and openness factor of the fabric contributes to the amount of light that is transmitted through the curtains and the see-through visibility of the curtains. Although the color and weave of these curtains may be varied to suit the aesthetics of the interior décor, the appearance of the windows is altered by the presence of the curtains.

The curtains may either be anchored at the top and bottom of the window frame or anchored at the top only and outfitted with a weighted hem. The curtain needs to be extra long with the surplus either wound around a dynamic tension retainer or stored in a reservoir housing. When an explosion occurs, the curtain feeds out of the receptacle to absorb the force of the flying glass fragments. The effectiveness of the blast curtains relies on their use and no protection is provided when these curtains are pulled away from the glazing.

Rigid catch bar systems have been designed and tested as a means of increasing the effectiveness of laminated window upgrades. Laminated glazing is designed to hold the glass shards together as the window is damaged; however, unless the window frames and attachments are upgraded as well to withstand the capacity of the glazing, this retrofit will not prevent the entire sheet from flying free of the window frames. The rigid catch bars intercept the laminated glass and disrupt their flight; however, they are limited in their effectiveness, tending to break the dislodged façade materials into smaller projectiles.

Rigid catch bar systems collect huge forces upon impact and require substantial anchorage into a very substantial structure to prevent failure. If either the attachments or the supporting structure are incapable of restraining the forces, the catch system will be dislodged and become part of the debris. Alternatively, the debris may be sliced by the rigid impact and the effectiveness of the catch bar will be severely reduced.

Flexible catch bars can be designed to absorb a significant amount of the energy upon impact, thereby keeping the debris intact and impeding their flight. These systems may be designed to effectively repel the debris and inhibit their flight into the occupied spaces. These systems may be designed to repel the debris from the failed glazing as well as the walls in which the windows are mounted. The design of the debris restraint system must be strong enough to withstand the momentum transferred upon impact and the connections must be capable of transferring the forces to the supporting slabs and spandrel beams. However, under no circumstances can the design of the restraint system add significant amounts of mass to the structure that may be dislodged and present an even greater risk to the occupants of the building.

Cables are extensively used to absorb significant amounts of energy upon impact and their flexibility makes them easily adaptable to many situations. The diameter of the cable, the spacing of the strands, and the means of attachment are all critical in designing an effective catch system. These catch cable concepts have been used by protective design window manufacturers as restraints for laminated lites. The use of cable systems has long been recognized as an effective means of stopping massive objects moving at high velocity. To confirm the adequacy of the cable catch system to restrain the debris resulting from an explosive event, an analytical simulation or a physical test is required.

High performance energy absorbing cable catcher systems retain glass and frame fragments and limit the force transmitted to the supporting structure. These commercially available retrofit products consist of a series of ¼-inch diameter stainless steel cables connected with a shock-absorbing device to an aluminum box section, which is attached to the jambs, the underside of the header, and the topside of the sill. The energy absorbing characteristics allow the catch systems to be attached to relatively weakly constructed walls without the need for additional costly structural reinforcement. To reduce the possibility of slicing the laminated glass, the cable may either be sheathed in a tube or an aluminum strip may be affixed to the glass directly behind the cable.

Unreinforced CMU walls provide limited protection against air-blast due to explosions. When subjected to overload from air-blast, brittle unreinforced CMU walls will fail and the debris will be propelled into the interior of the structure, possibly causing severe injury or death to the occupants. This wall type has been prohibited for new construction where protection against explosive threats is required. Existing unreinforced CMU walls may be retrofitted with a sprayed-on polymer coating to improve their air-blast resistance. This innovative retrofit technique takes advantage of the toughness and resiliency of modern polymer materials to effectively deform and dissipate the blast energy while containing the shattered wall fragments. Although the sprayed walls may shatter in a blast event, the elastomer material remains intact and contains the debris.

The blast mitigation retrofit for unreinforced CMU walls consists of an interior and optional exterior layer of polyurea applied to exterior walls and ceilings. The polyurea provides a ductile and resilient membrane that catches and retains secondary fragmentation from the existing concrete block as it breaks apart in response to an air-blast wave. These fragments, if allowed to enter the occupied space, are capable of producing serious injury and death to occupants of the structure.

In lieu of the elastomer, an aramid (Geotextile) debris catching system may be attached to the structure by means of plates bolted through the floor and ceiling slabs. Similar to the elastomer retrofit, the aramid layer does not strengthen the wall; instead, it restrains the debris that would otherwise be hurled into the occupied spaces.

6.11 STRUCTURAL UPGRADES

It may not be possible for existing construction to be retrofitted to limit the extent of collapse to one floor on either side of the failed column. If the members are retrofitted to develop catenary behavior, the adjoining bays must be upgraded to resist the large lateral forces associated with this mode of response. This may require more extensive retrofit than is either feasible or desirable. In such a situation, it may be desirable to isolate the collapsed region rather than risk propagating the collapse to adjoining bays. The retrofit of existing structures to protect against a potential progressive collapse resulting from the detonation of a terrorist explosive threat may, therefore, best be achieved through the localized hardening of vulnerable columns. These columns need only be upgraded to a level of resistance that balances the capacities of all adjacent structural elements. At greater blast intensities, the resulting damage would be extensive and termed global collapse rather than progressive collapse. Attempts to upgrade the structure to conform to the alternate path approach will be invasive and potentially counterproductive. Care must be taken not to weaken a structure in the attempt to make it more robust.

Conventionally designed columns may be vulnerable to the effects of explosives, particularly when placed in contact with their surface. Stand-off elements, in the form of partitions and enclosures, may be designed to guarantee a minimum stand-off distance; however, this alone may not be sufficient. Additional resistance may be provided to reinforced concrete structures by means of a steel jacket or a carbon fiber wrap that effectively confines the concrete core, thereby increasing the confined strength and shear capacity of the column, and holds the rubble together to permit it to continue carrying the axial loads. The capacity of steel flanged columns may be increased with a reinforced concrete encasement that adds mass to the steel section and protects the relatively thin flange sections. The details for these retrofits must be designed to resist the specific weight of explosives and stand-off distance.

The floor slabs are typically designed to resist downward gravity loading and have limited capacity to resist uplift pressures or the upward deformations experienced during a load reversal. Therefore, floor slabs that may be subjected to significant uplift pressures, such that they overcome the gravity loads and subject the slabs to reversals in curvature, require additional reinforcement. If the slab does not contain this tension reinforcement, it must be supplemented with a lightweight carbon fiber application that may be bonded to the surface at the critical locations. Carbon fiber reinforcing mats bonded to the top surface of slabs would strengthen the floors for upward loading and reduce the likelihood of slab collapse from blast infill uplift pressures as well as internal explosions in mailrooms or other susceptible regions. This lightweight high tensile strength material will supplement the limited capacity of the concrete to resist these unnatural loading conditions. An alternative approach may be to notch grooves in the top of concrete slabs and epoxy carbon fiber rods into grooves; although this approach may offer a greater capacity, it is much more invasive and has not been evaluated with explosive testing.

RECOMMENDATIONS FOR BLAST PROTECTION

The following actions are recommended for blast protection:

- ❍ Increase the level of protection against an external detonation by applying any one of the fragment mitigating options summarized above to a renovated school gymnasium or auditorium safe room. The effectiveness of these measures will depend on advanced notification of a suspicious device and the distance from the explosive source.
- ❍ Develop plans, procedures, and training for sheltering in place as a protective action against a remote explosive threat. To support this protective measure, define a rapid notification system (public address system) and safe evacuation routes.
- ❍ Develop security procedures specific to entry screening for suspicious objects to reduce vulnerability to internal detonation. However, the decision to implement these procedures should be made on a case by case basis following a thorough risk analysis for the facility.

A

ADAAG Americans with Disabilities Act Accessibility Guidelines

AED automated external defibrillator

ANFO ammonium nitrate and fuel oil

APS apartment protected space

ASF anti-shatter film

ASZM-TEDA copper-silver-zinc-molybdenum-triethylenediamine

AT antiterrorism

ATF Bureau of Alcohol, Tobacco, and Firearms

B

BPL bound with pitch-low

BW biological warfare

C

CBR chemical, biological, or radiological

CCTV closed circuit television

CDC Centers for Disease Control and Prevention

CFD Computational Fluid Dynamics

cfm cubic feet per minute

CMU concrete masonry unit

CPR	cardiopulmonary resuscitation
CPTED	Crime Prevention Through Environmental Design
CWA	chemical warfare agent

D

DHS	Department of Homeland Security
DOC	Department of Commerce
DoD	Department of Defense
DOE	Department of Education
DOJ	Department of Justice
DOS	Department of State

E

EP&R	Directorate of Emergency Preparedness and Response (DHS)

F

FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FPS	floor protected space
FRF	fragment retention film

G

GC/MS	gas chromatograph/mass spectrometer
GIS	Geographic Information System
GSA	General Services Administration

H

HazMat	hazardous materials
HEGA	high-efficiency gas adsorber
HEPA	high-efficiency particulate air
HSO	Homeland Security Office
HVAC	heating, ventilation, and air conditioning

I

IAQ	indoor air quality
ID	identification
IDF	Israeli Defense Fund
IMS	ion mobility spectrometry
ISC	Interagency Security Committee
IT	information technology
iwg	inch water gauge

M

mph	miles per hour

N

NACCT National Advisory Committee on Children and Terrorism

NAVFAC Naval Facilities Command

NFPA National Fire Protection Association

NFPC National Fire Protection Code

NIOSH National Institute for Occupational Safety and Health

O

OC oleoresin capsicum

P

PIO Public Information Officer

psi pounds per square inch

pvb polyvinyl butyral

S

SAW surface acoustic wave

SRWF shatter-resistant window film

T

TEDA triethylenediamine

TIC toxic industrial chemical

TIM toxic industrial material

TNT trinitrotoluene

U

UFAS Uniform Federal Accessibility Standards

UFC Unified Facilities Criteria

U.K. United Kingdom

UPS uninterrupted power supply

U.S. United States

USACE U.S. Army Corps of Engineers

UV ultraviolet

V

VA Department of Veterans Affairs

This appendix contains some terms that do not actually appear in this manual. They have been included to present a comprehensive list that pertains to this series of publications.

A

Access control. Any combination of barriers, gates, electronic security equipment, and/or guards that can deny entry to unauthorized personnel or vehicles.

Access control point. A station at an entrance to a building or a portion of a building where identification is checked and people and hand-carried items are searched.

Access controls. Procedures and controls that limit or detect access to minimum essential infrastructure resource elements (e.g., people, technology, applications, data, and/or facilities), thereby protecting these resources against loss of integrity, confidentiality, accountability, and/or availability.

Accountability. The explicit assignment of responsibilities for oversight of areas of control to executives, managers, staff, owners, providers, and users of minimum essential infrastructure resource elements.

Active vehicle barrier. An impediment placed at an access control point that may be manually or automatically deployed in response to detection of a threat.

Aerosol. Fine liquid or solid particles suspended in a gas (e.g., fog or smoke).

Aggressor. Any person seeking to compromise a function or structure.

Airborne contamination. Chemical or biological agents introduced into and fouling the source of supply of breathing or conditioning air.

Antiterrorism (AT). Defensive measures used to reduce the vulnerability of individuals, forces, and property to terrorist acts.

Area lighting. Lighting that illuminates a large exterior area.

Assessment. The evaluation and interpretation of measurements and other information to provide a basis for decision-making.

Asset. A resource of value requiring protection. An asset can be tangible (e.g., people, buildings, facilities, equipment, activities, operations, and information) or intangible (e.g., processes or a company's information and reputation).

Asset protection. Security program designed to protect personnel, facilities, and equipment, in all locations and situations, accomplished through planned and integrated application of combating terrorism, physical security, operations security, and personal protective services, and supported by intelligence, counterintelligence, and other security programs.

Asset value. The degree of debilitating impact that would be caused by the incapacity or destruction of an asset.

Attack. A hostile action resulting in the destruction, injury, or death to the civilian population, or damage or destruction to public and private property.

B

Balanced magnetic switch. A door position switch utilizing a reed switch held in a balanced or center position by interacting magnetic fields when not in alarm condition.

Ballistics attack. An attack in which small arms (e.g., pistols, submachine guns, shotguns, and rifles) are fired from a distance and rely on the flight of the projectile to damage the target.

Barbed tape or concertina. A coiled tape or coil of wires with wire barbs or blades deployed as an obstacle to human trespass or entry into an area.

Barbed wire. A double strand of wire with four-point barbs equally spaced along the wire deployed as an obstacle to human trespass or entry into an area.

Barcode. A black bar printed on white paper or tape that can be easily read with an optical scanner.

Biological agents. Living organisms or the materials derived from them that cause disease in or harm to humans, animals, or plants or cause deterioration of material. Biological agents may be used as liquid droplets, aerosols, or dry powders.

Blast curtains. Heavy curtains made of blast-resistant materials that could protect the occupants of a room from flying debris.

Blast-resistant glazing. Window opening glazing that is resistant to blast effects because of the interrelated function of the frame and glazing material properties frequently dependent upon tempered glass, polycarbonate, or laminated glazing.

Blast vulnerability envelope. The geographical area in which an explosive device will cause damage to assets.

Bollard. A vehicle barrier consisting of a cylinder, usually made of steel and sometimes filled with concrete, placed on end in the ground and spaced about 3 feet apart to prevent vehicles from passing, but allowing entrance of pedestrians and bicycles.

Building hardening. Enhanced construction that reduces vulnerability to external blast and ballistic attacks.

Building separation. The distance between closest points on the exterior walls of adjacent buildings or structures.

C

Cable barrier. Cable or wire rope anchored to and suspended off the ground or attached to chain-link fence to act as a barrier to moving vehicles.

Chemical agent. A chemical substance that is intended to kill, seriously injure, or incapacitate people through physiological effects. Generally separated by severity of effect (e.g., lethal, blister, and incapacitating).

Clear zone. An area that is clear of visual obstructions and landscape materials that could conceal a threat or perpetrator.

Closed circuit television (CCTV). An electronic system of cameras, control equipment, recorders, and related apparatus used for surveillance or alarm assessment.

Collateral damage. Injury or damage to assets that are not the primary target of an attack.

Combating terrorism. The full range of federal programs and activities applied against terrorism, domestically and abroad, regardless of the source or motive.

Community. A political entity that has the authority to adopt and enforce laws and ordinances for the area under its jurisdiction. In most cases, the community is an incorporated town, city, township, village, or unincorporated area of a county; however, each state defines its own political subdivisions and forms of government.

Components and cladding. Elements of the building envelope that do not qualify as part of the main wind-force resisting system.

Confidentiality. The protection of sensitive information against unauthorized disclosure and sensitive facilities from physical, technical, or electronic penetration or exploitation.

Consequence Management. Measures to protect public health and safety, restore essential government services, and provide emergency relief to governments, businesses, and individuals affected by the consequences of terrorism. State and local governments exercise the primary authority to respond to the consequences of terrorism.

Contamination. The undesirable deposition of a chemical, biological, or radiological material on the surface of structures, areas, objects, or people.

Control center. A centrally located room or facility staffed by personnel charged with the oversight of specific situations and/ or equipment.

Controlled area. An area into which access is controlled or limited. It is that portion of a restricted area usually near or surrounding a limited or exclusion area. Correlates with exclusion zone.

Controlled lighting. Illumination of specific areas or sections.

Controlled perimeter. A physical boundary at which vehicle and personnel access is controlled at the perimeter of a site. Access control at a controlled perimeter should demonstrate the capability to search individuals and vehicles.

Conventional construction. Building construction that is not specifically designed to resist weapons, explosives, or chemical, biological, and radiological effects. Conventional construction is designed only to resist common loadings and environmental effects such as wind, seismic, and snow loads.

Coordinate. To advance systematically an exchange of information among principals who have or may have a need to know certain information in order to carry out their roles in a response.

Counterintelligence. Information gathered and activities conducted to protect against: espionage, other intelligence activities, sabotage, or assassinations conducted for or on behalf of foreign powers, organizations, or persons; or international terrorist activities, excluding personnel, physical, document, and communications security programs.

Counterterrorism (CT). Offensive measures taken to prevent, deter, and respond to terrorism.

Covert entry. Attempts to enter a facility by using false credentials or stealth.

Crash bar. A mechanical egress device located on the interior side of a door that unlocks the door when pressure is applied in the direction of egress.

Crime Prevention Through Environmental Design (CPTED). A crime prevention strategy based on evidence that the design and form of the built environment can influence human behavior. CPTED usually involves the use of three principles: natural surveillance (by placing physical features, activities, and people to maximize visibility); natural access control (through the judicial placement of entrances, exits, fencing, landscaping, and lighting); and territorial reinforcement (using buildings, fences, pavement, signs, and landscaping to express ownership).

Crisis Management (CM). The measures taken to identify, acquire, and plan the use of resources needed to anticipate, prevent, and/or resolve a threat or act of terrorism.

Critical assets. Those assets essential to the minimum operations of the organization, and to ensure the health and safety of the general public.

Critical infrastructure. Primary infrastructure systems (e.g., utilities, telecommunications, transportation, etc.) whose incapacity would have a debilitating impact on the school's ability to function.

D

Damage assessment. The process used to appraise or determine the number of injuries and deaths, damage to public and private property, and the status of key facilities and services (e.g., schools, hospitals and other health care facilities, fire and police stations, communications networks, water and sanitation systems, utilities, and transportation networks) resulting from a manmade or natural disaster.

Data gathering panel. A local processing unit that retrieves, processes, stores, and/or acts on information in the field.

Debris-catching system. Blast wallpaper, fragmentation blankets, or any similar system applied to the inside of a building's exterior walls. Debris-catching systems are often made of Kevlar or geotextile material and are designed to collect wall material debris in the event of an external explosion and to shield occupants from injuries.

Decontamination. The reduction or removal of a chemical, biological, or radiological material from the surface of a structure, area, object, or person.

Defense layer. Building design or exterior perimeter barriers intended to delay attempted forced entry.

Defensive measures. Protective measures that delay or prevent attack on an asset or that shield the asset from weapons, explosives, and CBR effects. Defensive measures include site work and building design.

Design Basis Threat (DBT). The threat (e.g., tactics and associated weapons, tools, or explosives) against which assets within a building must be protected and upon which the security engineering design of the school is based.

Design constraint. Anything that restricts the design options for a protective system or that creates additional problems for which the design must compensate.

Design opportunity. Anything that enhances protection, reduces requirements for protective measures, or solves a design problem.

Design team. A group of individuals from various engineering and architectural disciplines responsible for the protective system design.

Disaster. An occurrence of a natural catastrophe, technological accident, or human-caused event that has resulted in severe property damage, deaths, and/or multiple injuries.

Domestic terrorism. The unlawful use, or threatened use, of force or violence by a group or individual based and operating entirely within the United States or Puerto Rico without foreign direction committed against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof in furtherance of political or social objectives.

Dose rate (radiation). A general term indicating the quantity (total or accumulated) of ionizing radiation or energy absorbed by a person or animal, per unit of time.

Dosimeter. An instrument for measuring and registering total accumulated exposure to ionizing radiation.

Duress alarm devices. Also known as panic buttons, these devices are designated specifically to initiate a panic alarm.

E

Effective stand-off distance. A stand-off distance at which the required level of protection can be shown to be achieved through analysis or can be achieved through building hardening or other mitigating construction or retrofit.

Electronic Entry Control Systems (EECS). Electronic devices that automatically verify authorization for a person to enter or exit a controlled area.

Electronic Security System (ESS). An integrated system that encompasses interior and exterior sensors, closed circuit television systems for assessment of alarm conditions, Electronic Entry Control Systems, data transmission media, and alarm reporting systems for monitoring, control, and display of various alarm and system information.

Emergency. Any natural or human-caused situation that results in or may result in substantial injury or harm to the population or substantial damage to or loss of property.

Emergency Environmental Health Services. Services required to correct or improve damaging environmental health effects on humans, including inspection for food contamination, inspection for water contamination, and vector control; providing for sewage and solid waste inspection and disposal; cleanup and disposal of hazardous materials; and sanitation inspection for emergency shelter facilities.

Emergency Medical Services (EMS). Services including personnel, facilities, and equipment required to ensure proper medical care for the sick and injured from the time of injury to the time of final disposition, including medical disposition within a hospital, temporary medical facility, or special care facility; release from the site; or declared dead. Further, Emergency Medical Services specifically include those services immediately required to ensure proper medical care and specialized treatment for patients in a hospital and coordination of related hospital services.

Emergency Operations Center (EOC). The protected site from which state and local civil government officials coordinate, monitor, and direct emergency response activities during an emergency.

Emergency Operations Plan (EOP). A document that describes how people and property will be protected in disaster and disaster threat situations; details who is responsible for carrying out specific actions; identifies the personnel, equipment, facilities, supplies, and other resources available for use in the disaster; and outlines how all actions will be coordinated.

Emergency Public Information (EPI). Information that is disseminated primarily in anticipation of an emergency or at the actual time of an emergency and, in addition to providing information, frequently directs actions, instructs, and transmits direct orders.

Entry control point. A continuously or intermittently manned station at which entry to sensitive or restricted areas is controlled.

Equipment closet. A room where field control equipment such as data gathering panels and power supplies are typically located.

Evacuation. Organized, phased, and supervised dispersal of people from dangerous or potentially dangerous areas.

Evacuation, mandatory or directed. This is a warning to persons within the designated area that an imminent threat to life and property exists and individuals MUST evacuate in accordance with the instructions of local officials.

Evacuation, spontaneous. Residents or citizens in the threatened areas observe an emergency event or receive unofficial word of an actual or perceived threat and, without receiving instructions to do so, elect to evacuate the area. Their movement, means, and direction of travel are unorganized and unsupervised.

Evacuation, voluntary. This is a warning to persons within a designated area that a threat to life and property exists or is likely to exist in the immediate future. Individuals issued this type of warning or order are NOT required to evacuate; however, it would be to their advantage to do so.

Evacuees. All persons removed or moving from areas threatened or struck by a disaster.

Exclusion area. A restricted area containing a security interest. Uncontrolled movement permits direct access to the item. See controlled area and limited area.

Exclusion zone. An area around an asset that has controlled entry with highly restrictive access. See controlled area.

F

Federal Coordinating Officer (FCO). The person appointed by the FEMA Director to coordinate federal assistance in a Presidentially declared emergency or major disaster.

Federal Response Plan (FRP). The FRP establishes a process and structure for the systematic, coordinated, and effective delivery of federal assistance to address the consequences of any major disaster or emergency.

Fence protection. An intrusion detection technology that detects a person crossing a fence by various methods such as climbing, crawling, cutting, etc.

Fence sensor. An exterior intrusion detection sensor that detects aggressors as they attempt to climb over, cut through, or otherwise disturb a fence.

Field of view. The visible area in a video picture.

First responder. Local police, fire, and emergency medical personnel who first arrive on the scene of an incident and take action to save lives, protect property, and meet basic human needs.

Forced entry. Entry to a denied area achieved through force to create an opening in fence, walls, doors, etc., or to overpower guards.

Fragment retention film (FRF). A thin, optically clear film applied to glass to minimize the spread of glass fragments when the glass is shattered.

Frangible construction. Building components that are designed to fail to vent blast pressures from an enclosure in a controlled manner and direction.

G

Glare security lighting. Illumination projected from a secure perimeter into the surrounding area, making it possible to see potential intruders at a considerable distance while making it difficult to observe activities within the secure perimeter.

Glazing. A material installed in a sash, ventilator, or panes (e.g., glass, plastic, etc., including material such as thin granite installed in a curtain wall).

Governor's Authorized Representative (GAR). The person empowered by the Governor to execute, on behalf of the State, all necessary documents for disaster assistance.

H

Hazard. A source of potential danger or adverse condition.

Hazard mitigation. Any action taken to reduce or eliminate the long-term risk to human life and property from hazards. The term is sometimes used in a stricter sense to mean cost-effective measures to reduce the potential for damage to a facility or facilities from a disaster event.

Hazardous material (HazMat). Any substance or material that, when involved in an accident and released in sufficient quantities, poses a risk to people's health, safety, and/or property. These substances and materials include explosives, radioactive materials, flammable liquids or solids, combustible liquids or solids, poisons, oxidizers, toxins, and corrosive materials.

High-hazard areas. Geographic locations that, for planning purposes, have been determined through historical experience and vulnerability analysis to be likely to experience the effects of a specific hazard (e.g., hurricane, earthquake, hazardous materials accident, etc.), resulting in vast property damage and loss of life.

High-risk target. Any material resource or facility that, because of mission sensitivity, ease of access, isolation, and symbolic value, may be an especially attractive or accessible terrorist target.

Human-caused hazard. Human-caused hazards are technological hazards and terrorism. They are distinct from natural hazards primarily in that they originate from human activity. Within the military services, the term threat is typically used for human-caused hazard. See definitions of technological hazards and terrorism for further information.

International terrorism. Violent acts or acts dangerous to human life that are a violation of the criminal laws of the United States or any state, or that would be a criminal violation if committed within the jurisdiction of the United States or any state. These acts appear to be intended to intimidate or coerce a civilian population, influence the policy of a government by intimidation or coercion, or affect the conduct of a government by assassination or kidnapping. International terrorist acts occur outside the United States, or transcend national boundaries in terms of the means by which they are accomplished, the persons they appear intended to coerce or intimidate, or the locale in which their perpetrators operate or seek asylum.

Intrusion Detection System (IDS). The combination of components, including sensors, control units, transmission lines, and monitor units, integrated to operate in a specified manner.

J

Jersey barrier. A protective concrete barrier initially and still used as a highway divider that now also functions as an expedient method for traffic speed control at entrance gates and to keep vehicles away from buildings.

L

Laminated glass. A flat lite of uniform thickness consisting of two monolithic glass plies bonded together with an interlayer material as defined in Specification C1172. Many different interlayer materials are used in laminated glass.

Landscaping. The use of plantings (shrubs and trees), with or without landforms and/or large boulders, to act as a perimeter barrier against defined threats.

Layers of protection. A traditional approach in security engineering using concentric circles extending out from an area to be protected as demarcation points for different security strategies.

Level of protection (LOP). The degree to which an asset is protected against injury or damage from an attack.

Liaison. An agency official sent to another agency to facilitate interagency communications and coordination.

Limited area. A restricted area within close proximity of a security interest. Uncontrolled movement may permit access to the item. Escorts and other internal restrictions may prevent access to the item. See controlled area and exclusion area.

Line of sight (LOS). Direct observation between two points with the naked eye or hand-held optics.

Line-of-sight sensor. A pair of devices used as an intrusion detection sensor that monitor any movement through the field between the sensors.

Local government. Any county, city, village, town, district, or political subdivision of any state, and Indian tribe or authorized tribal organization, or Alaska Native village or organization, including any rural community or unincorporated town or village or any other public entity.

M

Mail-bomb delivery. Bombs or incendiary devices delivered to the target in letters or packages.

Minimum measures. Protective measures that can be applied to all buildings regardless of the identified threat. These measures offer defense or detection opportunities for minimal cost, facilitate future upgrades, and may deter acts of aggression.

Mitigation. Those actions taken to reduce the exposure to and impact of an attack or disaster.

Motion detector. An intrusion detection sensor that changes state based on movement in the sensor's field of view.

Moving vehicle bomb. An explosive-laden car or truck driven into or near a building and detonated.

Mutual Aid Agreement. A pre-arranged agreement developed between two or more entities to render assistance to the parties of the agreement.

N

Natural hazard. Naturally-occurring events such as floods, earthquakes, tornadoes, tsunami, coastal storms, landslides, and wildfires that strike populated areas. A natural event is a hazard when it has the potential to harm people or property (FEMA 386- 2 *Understanding Your Risks*). The risks of natural hazards may be increased or decreased as a result of human activity; however, they are not inherently human-induced.

Natural protective barriers. Natural protective barriers are mountains and deserts, cliffs and ditches, water obstacles, or other terrain features that are difficult to traverse.

Non-exclusive zone. An area around an asset that has controlled entry, but shared or less restrictive access than an exclusive zone.

Non-persistent agent. An agent that, upon release, loses its ability to cause casualties after 10 to 15 minutes. It has a high evaporation rate, is lighter than air, and will disperse rapidly. It is considered to be a short-term hazard; however, in small, unventilated areas, the agent will be more persistent.

Nuclear, biological, or chemical weapons. Also called Weapons of Mass Destruction (WMD). Weapons that are characterized by their capability to produce mass casualties.

P

Passive vehicle barrier. A vehicle barrier that is permanently deployed and does not require response to be effective.

Perimeter barrier. A fence, wall, vehicle barrier, landform, or line of vegetation applied along an exterior perimeter used to obscure vision, hinder personnel access, or hinder or prevent vehicle access.

Persistent agent. An agent that, upon release, retains its casualty producing effects for an extended period of time, usually anywhere from 30 minutes to several days. A persistent agent usually has a low evaporation rate and its vapor is heavier thanair; therefore, its vapor cloud tends to hug the ground. It is considered to be a long-term hazard. Although inhalation hazards are still a concern, extreme caution should be taken to avoid skin contact as well.

Physical security. The part of security concerned with measures/ concepts designed to safeguard personnel; to prevent unauthorized access to equipment, installations, materiel, and documents; and to safeguard them against espionage, sabotage, damage, and theft.

Planter barrier. A passive vehicle barrier, usually constructed of concrete and filled with dirt (and flowers for aesthetics). Planters, along with bollards, are the usual street furniture used to keep vehicles away from existing buildings. Overall size and the depth of installation below grade determine the vehicle stopping capability of the individual planter.

Plume. Airborne material spreading from a particular source; the dispersal of particles, gases, vapors, and aerosols into the atmosphere.

Polycarbonate glazing. A plastic glazing material with enhanced resistance to ballistics or blast effects.

Preliminary Damage Assessment (PDA). A mechanism used to determine the impact and magnitude of damage and the resulting unmet needs of individuals, businesses, the public sector, and the community as a whole. Information collected is used by the state as a basis for the Governor's request for a Presidential declaration, and by FEMA to document the recommendation made to the President in response to the Governor's request. PDAs are made by at least one state and one federal representative. A local government representative familiar with the extent and location of damage in the community often participates; other state and federal agencies and voluntary relief organizations also may be asked to participate, as needed.

Preparedness. Establishing the plans, training, exercises, and resources necessary to enhance mitigation of and achieve readiness for response to, and recovery from all hazards, disasters, and emergencies, including WMD incidents.

Primary asset. An asset that is the ultimate target for compromise by an aggressor.

Primary gathering building. Inhabited buildings routinely occupied by 50 or more personnel. This designation applies to the entire portion of a building that meets the population density requirements for an inhabited building.

Probability of detection (POD). A measure of an intrusion detection sensor's performance in detecting an intruder within its detection zone.

Probability of intercept. The probability that an act of aggression will be detected and that a response force will intercept the aggressor before the asset can be compromised.

Progressive collapse. A chain reaction failure of building members to an extent disproportionate to the original localized damage. Such damage may result in upper floors of a building collapsing onto lower floors.

Protective barriers. Define the physical limits of a site, activity, or area by restricting, channeling, or impeding access and forming a continuous obstacle around the object.

Protective measures. Elements of a protective system that protect an asset against a threat. Protective measures are divided into defensive and detection measures.

Protective system. An integration of all of the protective measures required to protect an asset against the range of threats applicable to the asset.

R

Radiation. High-energy particles or gamma rays that are emitted by an atom as the substance undergoes radioactive decay. Particles can be either charged alpha or beta particles or neutral neutron or gamma rays.

Radiation sickness. The symptoms characterizing the sickness known as radiation injury, resulting from excessive exposure of the whole body to ionizing radiation.

Radiological monitoring. The process of locating and measuring radiation by means of survey instruments that can detect and measure (as exposure rates) ionizing radiation.

Recovery. The long-term activities beyond the initial crisis period and emergency response phase of disaster operations that focus on returning all systems in the community to a normal status or to reconstitute these systems to a new condition that is less vulnerable.

Response. Executing the plan and resources identified to perform those duties and services to preserve and protect life and property as well as provide services to the surviving population.

Restricted area. Any area with access controls that is subject to these special restrictions or controls for security reasons. See controlled area, limited area, exclusion area, and exclusion zone.

Risk. The potential for loss of, or damage to, an asset. It is measured based upon the value of the asset in relation to the threats and vulnerabilities associated with it.

Rotating drum or rotating plate vehicle barrier. An active vehicle barrier used at vehicle entrances to controlled areas based on a drum or plate rotating into the path of the vehicle when signaled.

S

Sacrificial roof or wall. Roofs or walls that can be lost in a blast without damage to the primary asset.

Safe haven. Secure areas within the interior of the facility. A safe haven should be designed such that it requires more time to penetrate by aggressors than it takes for the response force to reach the protected area to rescue the occupants. It may be a haven from a physical attack or an air-isolated haven from CBR contamination.

Secondary asset. An asset that supports a primary asset and whose compromise would indirectly affect the operation of the primary asset.

Secondary hazard. A threat whose potential would be realized as the result of a triggering event that of itself would constitute an emergency (e.g., dam failure might be a secondary hazard associated with earthquakes).

Situational crime prevention. A crime prevention strategy based on reducing the opportunities for crime by increasing the effort required to commit a crime, increasing the risks associated with committing the crime, and reducing the target appeal or vulnerability (whether property or person). This opportunity reduction is achieved by management and use policies such as procedures and training, as well as physical approaches such as alteration of the built environment.

Specific threat. Known or postulated aggressor activity focused on targeting a particular asset.

Stand-off distance. A distance maintained between a building or portion thereof and the potential location for an explosive detonation or other threat.

Stand-off weapons. Weapons such as anti-tank weapons and mortars that are launched from a distance at a target.

State Coordinating Officer (SCO). The person appointed by the Governor to coordinate state, commonwealth, or territorial response and recovery activities with FRP-related activities of the Federal Government, in cooperation with the FCO.

State Liaison. A FEMA official assigned to a particular state, who handles initial coordination with the state in the early stages of an emergency.

Stationary vehicle bomb. An explosive-laden car or truck stopped or parked near a building.

Structural protective barriers. Manmade devices (e.g., fences, walls, floors, roofs, grills, bars, roadblocks, signs, or other construction) used to restrict, channel, or impede access.

Superstructure. The supporting elements of a building above the foundation.

Supplies-bomb delivery. Bombs or incendiary devices concealed and delivered to supply or material handling points such as loading docks.

T

Tactics. The specific methods of achieving the aggressor's goals to injure personnel, destroy assets, or steal materiel or information.

Tangle-foot wire. Barbed wire or tape suspended on short metal or wooden pickets outside a perimeter fence to create an obstacle to approach.

Taut wire sensor. An intrusion detection sensor utilizing a column of uniformly spaced horizontal wires, securely anchored at each end and stretched taut. Each wire is attached to a sensor to indicate movement of the wire.

Technological hazards. Incidents that can arise from human activities such as manufacture, transportation, storage, and use of hazardous materials. For the sake of simplicity, it is assumed that technological emergencies are accidental and that their consequences are unintended.

Terrorism. The unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives.

Thermally tempered glass (TTG). Glass that is heat-treated to have a higher tensile strength and resistance to blast pressures, although with a greater susceptibility to airborne debris.

Threat. Any indication, circumstance, or event with the potential to cause loss of, or damage to an asset.

Threat analysis. A continual process of compiling and examining all available information concerning potential threats and human-caused hazards. A common method to evaluate terrorist groups is to review the factors of existence, capability, intentions, history, and targeting.

TNT equivalent weight. The weight of TNT (trinitrotoluene) that has an equivalent energetic output to that of a different weight of another explosive compound.

Tornado. A local atmospheric storm, generally of short duration, formed by winds rotating at very high speeds, usually in a counter-clockwise direction. The vortex, up to several hundred yards wide, is visible to the observer as a whirlpool-like column of winds rotating about a hollow cavity or funnel. Winds may reach 300 miles per hour or higher.

Toxic-free area. An area within a facility in which the air supply is free of toxic chemical or biological agents.

Toxicity. A measure of the harmful effects produced by a given amount of a toxin on a living organism.

Triple-standard concertina (TSC) wire. This type of fence uses three rolls of stacked concertina. One roll will be stacked on top of two other rolls that run parallel to each other while resting on the ground, forming a pyramid.

U

Unobstructed space. Space around an inhabited building without obstruction large enough to conceal explosive devices 150 mm (6 inches) or greater in height.

V

Video motion detection. Motion detection technology that looks for changes in the pixels of a video image.

Visual surveillance. The aggressor uses ocular and photographic devices (such as binoculars and cameras with telephoto lenses) to monitor facility or installation operations or to see assets.

Volumetric motion sensor. An interior intrusion detection sensor that is designed to sense aggressor motion within a protected space.

Vulnerability. Any weakness in an asset or mitigation measure than can be exploited by an aggressor (potential threat element), adversary, or competitor. It refers to the organization's susceptibility to injury.

W

Warning. The alerting of emergency response personnel and the public to the threat of extraordinary danger and the related effects that specific hazards may cause.

Watch. Indication in a defined area that conditions are favorable for the specified type of severe weather (e.g., flash flood watch, severe thunderstorm watch, tornado watch, tropical storm watch).

Waterborne contamination. Chemical, biological, or radiological agent introduced into and fouling a water supply.

Weapons of Mass Destruction (WMD). Any device, material, or substance used in a manner, in a quantity or type, or under circumstances showing an intent to cause death or serious injury to persons, or significant damage to property. An explosive, incendiary, or poison gas, bomb, grenade, rocket having a propellant charge of more than 4 ounces, or a missile having an explosive incendiary charge of more than 0.25 ounce, or mine or device similar to the above; poison gas; weapon involving a disease organism; or weapon that is designed to release radiation or radioactivity at a level dangerous to human life.

CHEMICAL WARFARE AGENT CHARACTERISICS

PHYSICAL AND CHEMICAL PROPERTIES

Agent Type	Chemical Agent; **Symbol** Chemical Structure	Molecular Weight	State @ 20°C	Odor	Vapor Density (Air = 1)	Liquid Density (g/cc)	Freezing/ Melting Point (°C)	Boiling Point (°C)	Vapor Pressure (mm/Hg)	Volatility (mg/m³)	Heat of Vaporization (cal/g)	Decomposition Temperature (°C)	Flash Point	Stability
NERVE	Tabun; **GA** $C_2H_5OPO(CN)N(CH_3)_2$	162.3	Colorless to brown liquid	Faintly fruity; none when pure	5.63	1.073 at 25°C	-5	240	0.037 @ 20°C	610 @ 25°C	79.56	150	78°C	Stable in steel at normal temperatures
	Sarin; **GB** $CH_3PO(F)OCH(CH_3)_2$	140.1	Colorless liquid	Almost none when pure	4.86	1.0887 at 25°C	-56	158	2.9 @ 25°C; 2.10 @ 20°C	22,000 @ 25°C; 16,090 @ 20°C	80	150	Non-flammable	Stable when pure
	Soman; **GD** $CH_3PO(F)OCH(CH_3)C(CH_3)_3$	182.178	Colorless liquid	Fruity; camphor when impure	6.33	1.0222 at 25°C	-42	198	0.4 @ 25°C	3,900 @ 25°C	72.4	130	High enough not to interfere w/ military use	Less stable than GA or GB
	(Cyclo-sarin); **GF** $CH_3PO(F)OC_6H_{11}$	180.2	Liquid	Sweet; musty; peaches; shellac	6.2	1.1327 at 20°C	-30	239	0.044 @ 20°C	438 @ 20°C	90.5	---	94°C	Relatively stable in steel
	VX $(C_2H_5O)(CH_3O)P(O)S(C_2H_4)N[C_2H_4(CH_3)_2]_2$	267.38	Colorless to amber liquid	None	9.2	1.0083 at 20°C	below -51	298	0.0007 @ 20°C	10.5 @ 25°C	78.2 @ 25°C	Half-life of 36 hr at 150	159°C	Relatively stable at room temperature
	V_x ("V sub x")	211.2	Colorless liquid	None	7.29	1.062 at 20°C	---	256	0.007 @ 25°C; 0.004 @ 20°C	75 @ 25°C; 48 @ 20°C	67.2	---	---	Relatively stable
BLISTER	Distilled Mustard; **HD** $(ClCH_2CH_2)_2S$	159.08	Colorless to pale yellow liquid	Garlic or horseradish	5.4	1.268 @ 25°C; 1.27 @ 20°C	14.45	217	0.072 @ 20°C	610 @ 20°C	94	149 – 177	105°C; ignited by large explosive charges	Stable in steel or aluminum
	Nitrogen Mustard; **HN-1** $(ClCH_2CH_2)_2NC_2H_5$	170.08	Dark liquid	Fishy or musty	5.9	1.09 @ 20°C	-34	194	0.24 @ 25°C	1,520 @ 20°C	77	Decomposes before boiling is reached	High enough not to interfere w/ military use	Adequate
	Nitrogen Mustard; **HN-2** $(ClCH_2CH_2)_2NCH_3$	156.07	Dark liquid	Soapy (low concentrations); Fruity (high)	5.4	1.15 @ 20°C	-65 to -60	75 at 15mmHg	0.29 @ 20°C	3,580 @ 25°C	78.8	Below boiling; polymerizes with heat generation	High enough not to interfere w/ military use	Unstable
	Nitrogen Mustard; **HN-3** $N(CH_2CH_2Cl)_3$	204.54	Dark liquid	None, if pure	7.1	1.24 @ 20°C	-37	256	0.0109 @ 25°C	121 @ 25°C	74	Below boiling point	High enough not to interfere w/ military use	Stable
	Phosgene oximedichloroforoxime; **CX** CCl_2NOH	113.94	Colorless solid or liquid	Sharp, penetrating	3.9	--	35 to 40	53 –54 at 28mmHg	11.2 @ 25°C (solid); 13 @ 40°C (liquid)	1,800 @ 20°C	101 at 40°C	Decomposes slowly at normal temperature	—	Decomposes slowly
	Lewisite; **L** $ClCHCHAsCl_2$	207.35	Colorless to brownish	Varies; may resemble geraniums	7.1	1.89 @ 20°C	-18	190	0.394 @ 20°C	4,480 @ 20°C	58 at 0°C to 190°C	>100	None	Stable in steel and glass
	Mustard-Lewisite mixture; **HL**	186.4	Dark, oily liquid	Garlic	6.5	1.66 @ 20°C	-25.4 (pure)	<190	0.248@ 20°C	2,730 @ 20°C	58 to 94	>100	High enough not to interfere w/ military use	Stable in lacquered steel
	Phenyldichlorarsine; **PD** $C_6H_5AsCl_2$	222.91	Colorless liquid	None	7.7	1.65 @ 20°C	-20	252 to 255	0.033 @ 25°C	390 @ 25°C	69	Stable to boiling point	High enough not to interfere w/ military use	Very stable
	Ethyldichlorarsine; **ED** $C_2H_5AsCl_2$	174.88	Colorless liquid	Fruity, but biting; irritating	6.0	1.66 @ 20°C	-65	156	2.09 @ 20°C	20,000 @ 20°C	52.5	Stable to boiling point	High enough not to interfere w/ military use	Stable in steel
	Methyldichlorarsine; **MD** CH_3AsCl_2	160.86	Colorless liquid	None	5.5	1.836 @ 20°C	-55	133	7.76 @ 20°C	74,900 @ 20°C	49	Stable to boiling point	High enough not to interfere w/ military use	Stable in steel
BLOOD	Hydrogen cyanide; **AC** HCN	27.02	Colorless gas or liquid	Bitter almonds	0.990 @ 20°C	0.687 @ 20°C	-13.3	25.7	742 @ 25°C; 612 @ 20°C	1,080,000 @ 25°C	233	>65.5	0°C; ignited 50% of time when disseminated by artillery shells	Stable if pure; can burn on explosion
	Cyanogen chloride; **CK** CNCl	61.48	Colorless gas or liquid	Pungent, biting; Can go unnoticed	2.1	1.18 @ 20°C	-6.9	12.8	1,000 @ 25°C	2,600,000 @ 20°C	103	100	None	Tends to polymerize; may explode
	Arsine; **SA** AsH_3	77.93	Colorless gas	Mild garlic	2.69	1.34 @ 20°C	-116	-62.5	11,100 @ 20°C	30,900,000 @ 20°C	53.7 @ -62.5°C	280	Below detonation temp.; mixtures w/ air may explode spontaneously	Not stable in uncoated metal containers
CHOKING	Phosgene; **CG** $COCl_2$	98.92	Colorless gas	New-mown hay; green corn	3.4	1.37 @ 20°C	-128	7.6	1.173 @ 20°C	4,300,000 @ 7.6°C	59	800	None	Stable in steel if dry
	Diphosgene; **DP** $ClCOOCCl_3$	197.85	Colorless gas	New-mown hay; green corn	6.8	1.65 @ 20°C	-57	127–128	4.2 @ 20°C	45,000 @ 20°C	57.4	300 to 350	None	Unstable; tends to convert to CG
VOMITING	Diphenylchlorarsine; **DA** $(C_6H_5)_2AsCl$	264.5	White to brown solid	None	Forms little vapor	1.387 @ 50°C	41 to 44.5	333	0.0036 @ 45°C	48 @ 45°C	56.6	300	350	Stable if pure
	Adamsite; **DM** $C_6H_4(AsCl)\text{-}NH)C_6H_4$	277.57	Yellow to green solid	None	Forms little vapor	1.65 (solid) @ 20°C	195	410	Negligible	Negligible	80	>boiling point	None	Stable in glass or steel
	Deiphenylcyanoarsine; **DC** $(C_6H_5)_2AsCN$	255.0	White to pink solid	Bitter almond-garlic mixture	Forms little vapor	1.3338 @ 35°C	31.5 to 35	350	0.0002 @ 20°C	2.8 @ 20°C	71.1	300 (25% decomposed)	Low	Stable at normal temperatures
Incapacitating	**BZ**	337.4	White crystal	None	11.6	Bulk 0.51 solid; Crystal 1.33	167.5	320	0.03 @ 70°C	0.5 @ 70°C	62.9	begins at 170°C	246°C	Adequate
TEAR	Chloroacetophenone; **CN** $C_6H_5COCH_2Cl$	154.59	Solid	Apple blossoms	5.3	1.318 (solid) @ 20°C	54	248	0.0041 @ 20°C	34.3 @ 20°C	98	Stable to boiling point	High enough not to interfere w/ military use	Stable
	Chloroacetophenone in Chloroform; **CNC**	128.17	Liquid	Chloroform	4.4	1.40 @ 20°C	0.23	variable, 60 to 247	127 @ 20°C	Indeterminate	n/a	Stable to boiling point	None	Adequate
	Chloroacetophenone and Chloropicrin in Chloroform; **CNS**	141.78	Liquid	Flypaper	~5	1.47 @ 20°C	2	variable, 60 to 247	78 @ 20°C	610,000 @ 20°C (includes solvent)	n/a	Stable to boiling point	None	Adequate
	Chloroacetophenone in Benzene and Carbon Tetrachloride; **CNB**	119.7	Liquid	Benzene	~4	1.14 @ 20°C	-7 to -30	variable 75 to 247	variable; mostly solvent vapor	Indeterminate	n/a	>247	<4.44°C	Adequate
	Bromobenzylcyanide; **CA** $BrC_6H_4CH_2CN$	196	Yellow or solid liquid	Soured fruit	6.7	1.47 @ 25°C	25.5	Decomposes at 242	0.011 @ 20°C	115 @ 20°C	79.5 @ 20°C	60 to 242	None	Fairly stable in glass, lead, or enamel
	O-chlorobenzylmalononitrile; **CS** $ClC_6H_4CHC(CN)_2$	188.5	Colorless solid	Pepper	---	1.04 @ 20°C	93 to 95	310 to 315	0.00034 @ 20°C	0.71 @ 25°C	53.6	---	197°C	Stable
	CR $(C_6H_4)_2(O)(N)CH$	195.25	Yellow powder in solution	Burning sensation	6.7	---	72	335	0.00059 @ 20°C	0.63 @ 25°C	---	---	188°C	Stable
	Chloropicrin; **PS** Cl_3CNO_2	164.38	Liquid	Stinging; pungent	5.6	1.66	-69	112	18.3 @ 20°C	165,000 @ 20°C	---	>400	Not flammable	Adequate; unstable in light

PHYSIOLOGICAL ACTION / **CWC**

Chemical Agent; **Symbol**	Median Lethal Dose (LD_{50}) (mg-min/m³)	Median Incapacitating Dose (ID_{50})	Eye & Skin Toxicity	Rate of Action	Physiological Action	Detoxification Rate	CWC Schedule
Tabun; **GA**	15,000 by skin (vapor) or 1500 (liquid); 70 inhaled	<50 inhaled	Very high	Very Rapid	Cessation of breath -- death may follow	Slight, but definite	1.A.(2)
Sarin; **GB**	10,000 by skin (vapor) or 1700 (liquid); 35 inhaled	25 inhaled	Very high	Very rapid	Cessation of breath – death may follow	cumulative	1.A.(1)
Soman; **GD**	2,500 by skin (vapor) or 350 (liquid); 35 inhaled	25 inhaled	Very high	Very rapid	Cessation of breath – death may follow	Low, essentially cumulative	1.A.(1)
(Cyclo-sarin); **GF**	2,500 by skin (vapor) or 350 (liquid); 35 inhaled	25 inhaled	Very high	Very rapid	Cessation of breath – death may follow	Low	1.A.(1)
VX	150 by skin (vapor) or 5 (liquid); 15 inhaled	25 by skin (vapor) or 2.5 (liquid); 10 inhaled	Very high	Very rapid	Produces casualties when inhaled or absorbed	low, essentially cumulative	1.A.(3)
V_x ("V sub x")	---	---	Very high	Rapid	Produces casualties when inhaled or absorbed	low, essentially cumulative	
Distilled Mustard; **HD**	900 (inhaled); 5,000 by skin (vapor) or 1,400 (liquid)	500 (skin); 100 (inhaled); 25 (eyes or nose)	Eyes very susceptible; skin less so	Delayed: hours to days	Blisters; destroys tissue; injures blood cells	Very low – cumulative	1.A.(4)
Nitrogen Mustard; **HN-1**	1,500 (inhaled); 20,000 (skin)	200 by eye; 9,000 by skin	Eyes susceptible to low concentration; skin less so	Delayed: 12 hours or longer	Blisters; affects respiratory tract; destroys tissue; injures blood cells	Not detoxified; cumulative	1.A.(6)
Nitrogen Mustard; **HN-2**	3,000 (inhaled)	<HN-1 & >HN-3; 100 by eye	Toxic to eyes; blisters skin	Skin – delayed 12 hrs or more; Eyes – faster than HD	Similar to HD; bronchopneumonia possible after 24 hours	Not detoxified; cumulative	1.A.(6)
Nitrogen Mustard; **HN-3**	1,500 (inhaled); 10,000 by skin (est.)	200 by eye; 2,500 by skin (est.)	Eyes very susceptible; skin less so	Serious effects same as HD; minor effects sooner	Similar to HN-2	Not detoxified – cumulative	1.A.(6)
Phosgene oximedichloroforoxime; **CX**	3,200 (inhaled)	very low	Powerful irritant to eyes and nose; liquid corrosive to skin	Immediate effects on contact	Violently irritates mucous membranes, eyes, and nose; forms wheals rapidly	—	
Lewisite; **L**	1,200–1,500 (inhaled); 100,000 (skin)	<300 by eye; >1,500 to 2,000 by skin	Severe eye damage; skin less so	Rapid	Similar to HD, plus may cause systemic poisoning	Not detoxified	1.A.(5)
Mustard-Lewisite mixture; **HL**	15,000 (inhaled); >10,000 (skin)	200 by eye; 1,500 to 2,000 by skin	Very high	Prompt stinging; blistering agent about 13 hours	Similar to HD, plus may cause systemic poisoning	Not detoxified	1.A.(4); 1.A.(5)
Phenyldichlorarsine; **PD**	2,600 (inhaled)	16 as vomiting agent; 1,800 as blister	633 mg-min/m³ produces eye casualty; less toxic to skin	Immediate eye effects; skin effects in 30 to 60 minutes	Irritates; causes nausea, vomiting and blisters	Probably rapid	
Ethyldichlorarsine; **ED**	3,000-5,000 (inhaled); 100,000 (skin)	5 to 10 by inhalation	Vapor harmful on long exposure; liquid blisters <L	Immediate irritation; delayed blistering	Damages respiratory tract; effects eyes; blisters; can cause systemic poisoning	Rapid	
Methyldichlorarsine; **MD**	3,000 – 5,000 (est.)	25 by inhalation	Eye damage possible; blisters less than HD	Immediate irritation; delayed blistering	Irritates respiratory tract; injures lungs and eyes; Causes systemic poisoning	Rapid	
Hydrogen cyanide; **AC**	Varies widely with concentration	Varies with concentration	Moderate	Very rapid	Interferes with body tissues' oxygen use; accelerates rate of breathing	Rapid: 0.017 mg/kg/min	3.A.(3)
Cyanogen chloride; **CK**	11,000	7,000	Low; lacrimatory and irritating	Very rapid	Chokes, irritates, causes slow breathing rate	Rapid: 0.02 to 0.1 mg/kg/min	3.A.(2)
Arsine; **SA**	5,000	2,500	None	Delayed 2 hours to 11 days	Damages blood, liver, and kidneys	Low	
Phosgene; **CG**	3,200	1,600	None	Immediate to 3 hr. depending on conc.	Damages and floods lungs	Not detoxified – cumulative	3.A.(1)
Diphosgene; **DP**	3,200	1,600	Slightly lacrimatory	Immediate to 3 hr. depending on conc.	Damages and floods lungs	Not detoxified – cumulative	3.A.(1)
Diphenylchlorarsine; **DA**	15,000 (est.)	12 (>10 minutes)	Irritating; not toxic	Very rapid	Like cold symptoms, plus headache, vomiting, nausea	Moderate	
Adamsite; **DM**	Variable; avg.: 11,000	22 (1 min.); 8 (60 min. exposure)	Irritating; relatively not toxic	Very rapid	Like cold symptoms, plus headache, vomiting, nausea	Rapid in small amounts	
Deiphenylcyanoarsine; **DC**	10,000 (est.)	30 (30 sec); 20 (5 min. exposure)	Irritating; not toxic	More rapid than DM or DA	Like cold symptoms, plus headache, vomiting, nausea	Rapid	
BZ	200,000 (est.)	112	---	Delayed: 1 to 4 hours depending on exposure	Fast heart beat, vomiting, dry mouth, blurred vision, stupor, increasing random activity	---	2.A.(3)
Chloroacetophenone; **CN**	7,000 to 14,000	80	Temporarily severe eye irritation; mild skin irritation	Instantaneous	Causes tearing; irritates eyes and respiratory tract	Rapid	
Chloroacetophenone in Chloroform; **CNC**	11,000 (est.)	80	Temporarily severe eye irritation; mild skin irritation	Instantaneous	Cause tearing; irritates eyes and respiratory tract	Rapid	
Chloroacetophenone and Chloropicrin in Chloroform; **CNS**	11,400	60	Irritating; not toxic	Instantaneous	Vomiting and choking agent as well as a tear agent	Slow because of effect of PS	
Chloroacetophenone in Benzene and Carbon Tetrachloride; **CNB**	11,000 (est.)	80	Temporarily severe eye irritation; mild skin irritation	Instantaneous	Powerfully lacrimatory	Rapid	
Bromobenzylcyanide; **CA**	8,000 to 11,000 (est.)	30	Irritating; not toxic	Instantaneous	Irritates eyes and respiratory passages	Rapid in low dosage	
O-chlorobenzylmalononitrile; **CS**	61,000	10 to 20	Highly irritating; not toxic	Instantaneous	Highly irritating; not toxic	Rapid	
CR	---	0.15	Highly irritating; not toxic	Instantaneous	Irritates skin, eyes, nose, and throat	Moderate	
Chloropicrin; **PS**	2,000	9	Highly irritating	Instantaneous	Acts as tear, vomiting, and choking agent	Slow	3.A.(4)

Sources: U.S. Department of the Army, *Potential Military Chemical/Biological Agents and Compounds*, U.S. Army Field Manual 3-9, (NAVFAC P-467, AFR 355-'7), 12 December 1990. Washington, D.C.: U.S. Government Printing Office.

Committee on Toxicology, National Research Council. 1997. *Review of Acute Human-Toxicity Estimates for Selected Chemical Warfare Agents*. Washington, D.C.: National Academy Press.

Note:

Tables reduced for PDF purposes only. Tables appear as 11x17 horizontal foldout pages in the printed publication.

SELECTED BIOLOGICAL AGENT CHARACTERISICS

Agent Type	Disease/Condition Causative Agent/ Pathogen	Description of Agent	Transmissible Person to Person	Infectivity/ Lethality	Incubation Period	Duration of Illness	Persistence/ Stability	Vaccination/ Toxoids	Rate of Action	Symptoms	Treatment	Possible Means of Delivery
BACTERIA	Anthrax (inhalation) *Bacillus anthracis*	Rod-shaped, gram-positive, aerobic sporulating micro-organism, individual spores ~(1–1.2)x(3–5)μ	No	Moderate/ High	1–7 days	3–5 days	Spores are highly stable	Yes	Symptoms in 2–3 days; Shock and death occurs with 24–36 hrs after symptoms	Fever, malaise, fatigue, cough and mild chest discomfort, followed by severe respiratory distress with dyspnea, diaphoresis, stridor, and cyanosis	Usually not effective after symptoms are present, high dose antibiotic treatment with penicillin, ciprofloxacin, or doxycycline should be undertaken. Supportive therapy may be necessary.	Aerosol.
	Brucellosis *Brucella suis, melitensis & abortus*	All non-motile, non-sporulating, gram negative, aerobic bacterium; ~(0.5-1)x(1-2)μ	No	High/Low	Days to months	Weeks to months	Organisms are stable for several weeks in wet soil and food.	Yes	Highly variable, usually 6-60 days.	Chills, sweats, headache, fatigue, myalgias, arthralgias, and anorexia. Cough may occur. Complications include sacroiliitis, arthritis, vertebral osteomyelitis, epididymoorchitis, and rarely endocarditis.	Recommended treatment is doxycycline (200 mg/day) plus rifampin (900 mg/day) for 6 weeks.	Aerosol. Expected to mimic a natural disease.
	Cholera *Vibrio cholerae*	Short, curved, motile, gram-negative, non-sporulating rod. Strongly anaerobic, these organisms prefer alkaline and high salt environments.	Negl.	Low/Moderate-High	1-5 days	1 or more weeks	Unstable in aerosols and pure water, more so in polluted water.	Yes	Sudden onset after 1-5 day incubation period.	Initial vomiting and abdominal distension with little or no fever or abdominal pain. Followed rapidly by diarrhea, which may be either mild or profuse and watery, with fluid losses exceeding 5 to 10 liters or more per day. Without treatment, death may result from severe dehydration, hypovolemia, and shock.	Therapy consists of fluid and electrolyte replacement. Antibiotics will shorten the duration of diarrhea and thereby reduce fluid losses. Tetracycline, ampicillin, or trimethoprim-sulfamethoxazole are most commonly used.	1. Sabotage (food/water supply) 2. Aerosol
	Glanders *Burkholderia mallei*	Gram-negative bacillus primarily noted for producing disease in horses, mules, and donkeys	Negl.	/Moderate-High	10-14 days	N/A	N/A	No	N/A	Inhalational exposure produces fever, rigors, sweats, myalgia, headache, pleuritic chest pain, cervical adenopathy, splenomegaly, and generalized papular/pustular eruptions. Almost always fatal without treatment.	Few antibiotics have been evaluated *in vivo*. Sulfadiazine may be effective in some cases. Ciprofloxacin, doxycycline, and rifampin have *in vitro* efficacy. Extrapolating from melioidosis guidelines, a combination of TMP-SMX + ceftazidime ± gentamicin might be considered.	Aerosol.
	Plague (pneumonic, bubonic) *Yersinia pestis*	Rod-shaped, non-motile, non-sporulating, gram-negative, aerobic bacterium; ~(0.5-1)x(1-2)μ	High	High/Very High in untreated personnel, the mortality is 100%	2 to 6 days for bubonic and 3 to 4 days for pneumonic	1-2 days	Less important because of high transmissibility.	Yes	Two to three days	High fever, chills, headache, hemoptysis, and toxemia, progressing rapidly to dyspnea, sturdier, and cyanosis. Death results from respiratory failure, circulatory collapse, and a bleeding diathesis.	Early administration of antibiotics is very effective. Supportive therapy for pneumonic and septicemic forms is required.	May be delivered via contaminated vectors (fleas) causing bubonic type, or, more likely, via aerosol causing pneumonic type.
	Shigellosis *Shigella Dysenteriae*	Rod-shaped, gram-negative, non-motile, non-sporulating bacterium	Negl.	High/Low	1-7 days (usually 2-3)	N/A	Unstable in aerosols and pure water, more so in polluted water.	No	Symptoms usually within 2-3 days, however, known to demonstrate in as little as 12 hours or as long as 7 days.	Fever, nausea, vomiting, abdominal cramps, watery diarrhea, and occasionally, traces of blood in the feces. Symptoms range from mild to severe with some infected individuals not experiencing any symptoms.	The antibiotics commonly used for treatment are ampicillin, trimethoprim/sulfamethoxazole (also known as Bactrim® or Septra®), nalidixic acid, or ciprofloxacin. Persons with mild infections will usually recover quickly without antibiotic treatment. Antidiarrheal agents such as loperamide (Imodium®) or diphenoxylate with atropine (Lomotil®) are likely to make the illness worse and should be avoided.	Contaminated food or water
	Tularemia *Francisella tularensis*	Small, aerobic, non-sporulating, non-motile, gram-negative cocco-bacillus ~0.2x(0.2-0.7)μ	No	High/ Moderate if untreated	1-10 days	2 or more weeks	Not very stable	Yes	Three to five days	Ulceroglandular tularemia with local ulcer and regional lymphadenopathy, fever, chills, headache, and malaise. Typhoidal or septicemic tularemia presents with fever, headache, malaise, substernal discomfort, prostration, weight loss, and non-productive cough.	Administration of antibiotics with early treatment is very effective. Streptomycin – 1 gm I. M. q. 12 hrs x 10 10-14 d. Gentamicin – 3-5 mg/kg/day x 10-14 d.	Aerosol.
	Typhoid *Salmonella typhi*	Rod-shaped, motile, non-sporulating gram-negative bacterium	Negl.	Moderate/ Moderate if untreated	6-21 days	Several weeks	Stable	Yes	One to three days	Sustained fever, severe headache, malaise, anorexia, a relative bradycardia, splenomegaly, nonproductive cough in the early stage of the illness, and constipation more commonly than diarrhea.	Chloramphenicol amoxicillin or TMP-SMX. Quilone derivatives and third generation cephalusporins and supportive therapy.	Sabotage of food and water supplies.
RICKETTSIAE	Q-Fever *Coxiella burnetii*	Bacterium-like, gram-negative organism, pleomorphic 300-700 nm	No	High/Very low	10-20	2 days to 2 weeks	Stable	Yes	Onset may be sudden	Chills, retrobulbar headache, weakness, malaise and severe sweats.	Tetracycline or doxycycline are the treatment of choice and are given orally for 5 to 7 days.	May be a dust cloud either from a line source or a point source (downwind one-half mile or more).
	Typhus (classic) *Rickettsia prowazekii*	Non-motile, minute, coccoid or rod shaped rickettsiae, in pairs or chains, 300 nm	No	High/High	6-15 days	Weeks to months	Not very stable	No	Variable onset, often sudden. Terminates by rapid lysis after about 2 weeks of fever	Headache, chills, prostration, fever, and general pain. A macular eruption appears on the fifth to sixth day, initially on the upper trunk, followed by spread to the entire body, but usually not the face, palms, or soles.	Tetracyclines or chlormphenical orally in a loading dose of 2-3 g, followed by daily doses of 1-2 g/day in 4 divided doses until ind. becomes afebrile (usually 2 days) plus 1 day.	May be delivered via contaminated vectors (lice or fleas).
VIRUSES	Encephalitis	Lipid-enveloped virions of 50-60 nm dia., icosohedral nucleocapsid w. 2 glycoproteins										
	-Eastern/Western Equine Encephalitis (EEE, WEE)		Negl.	High/High	5-15 days	1-3 weeks	Relatively unstable	Yes		Inflammation of the mengies of the brain, headache, fever, dizziness, drowsiness or stupor, tremors or convulsions, muscular incoordination.	No specific treatment; supportive treatment is essential	Airborne spread possible.
	-Venezuelan Equine Encephalitis		Low	High/Low	1-6 days	Days to weeks	Relatively unstable	Yes	Sudden	Inflammation of the mengies of the brain, headache, fever, dizziness, drowsiness or stupor, tremors or convulsions, muscular incoordination.	No specific treatment; supportive treatment is essential	Airborne spread possible.
	Hemorrhagic Fever									Malaise, myalgias, headache, vomiting, and diarrhea may occur with any of the hemorrhagic fevers	No specific treatment; intensive supportive treatment is essential	Airborne spread possible.
	-Ebola Fever	Filovirus	Moderate	High/High	7-9 days	5-16 days	Relatively unstable	No		May also include a macular dermatologic eruption.		
	-Marburg	Filovirus	Moderate					No		May also include a macular dermatologic eruption.		
	-Yellow Fever	Flavivirus. Isosahedral nucleocapsid 37-50 nm diam., lipoprotein env. w/ short surface spikes	Negl.	High/High	3-6 days	1-2 weeks	Relatively unstable	Yes	Sudden			
	Variola Virus (Smallpox)	Asymmetric, brick-shaped, rounded corners; DNA virus	High	High/High	7-17 days	1-2 weeks	Stable	Yes	2-4 days	Malaise, fever, rigors, vomiting, headache, and backache. 2-3 days later lesions appear which quickly progress from macules to papules, and eventually to pustular vesicles. They are more abundant on the extremities and face, and develop synchronously.	No specific treatment; supportive treatment is essential	Airborne spread possible.
TOXIN	Botulinum Toxin	any of the seven distinct neurotoxins produced by the bacillus, *Clostridium botulinum*	No	NA/High	Variable (hours to days)	24-72 hours/Months if lethal	Stable	Yes	12-72 hours	Initial signs and symptoms include ptosis, generalized weakness, lassitude, and dizziness. Diminished salivation with extreme dryness of the mouth and throat may cause complaints of a sore throat. Urinary retention or ileus may also occur. Motor symptoms usually are present early in the disease; cranial nerves are affected first with blurred vision, diplopia, ptosis, and photophobia. Bulbar nerve dysfunction causes dysarthria, dysphonia, and dysphagia. This is followed by a symmetrical, descending, progressive weakness of the extremities along with weakness of the respiratory muscles. Development of respiratory failure may be abrupt.	(1) Respiratory failure—tracheostomy and ventilatory assistance, fatalities should be <5%. Intensive and prolonged nursing care may be required for recovery (which may take several weeks or even months). (2) Food-borne botulism and aerosol exposure—equine antitoxin is probably helpful, sometimes even after onset of signs of intoxication. Administration of antitoxin is reasonable if disease has not progressed to a stable state. Use requires pretesting for sensitivity to horse serum (and desensitization for those allergic). Disadvantages include rapid clearance by immune elimination, as well as a theoretical risk of serum sickness.	1. Sabotage (food/water supply) 2. Aerosol
	Ricin	Glycoprotein toxin (66,000 daltons) from the seed of the castor plant	No	NA/High	Hours	Days	Stable	Not effective	6-72 hours	Rapid onset of nausea, vomiting, abdominal cramps and severe diarrhea with vascular collapse; death has occurred on the third day or later. Following inhalation, one might expect nonspecific symptoms of weakness, fever, cough, and hypothermia followed by hypotension and cardiovascular collapse.	Management is supportive and should include maintenance of intravascular volume. Standard management for poison ingestion should be employed if intoxication is by the oral route.	Aerosol
	Staphylococcal enterotoxin B	One of several exotoxins produced by *Staphylococcus aureus*	No	NA/Low	Days to weeks	Days to weeks	Stable	Not effective	30 min-6 hours	Fever, chills, headache, myalgia, and nonproductive cough. In more severe cases, dyspnea and retrosternal chest pain may also be present. In many patients nausea, vomiting, and diarrhea will also occur.	Treatment is limited to supportive care. No specific antitoxin for human use is available.	1. Sabotage (food/water supply) 2. Aerosol
	Trichothecene (T-2) Mycotoxins	A diverse group of more than 40 compounds produced by fungi.	No	NA/High	Hours	Hours	Stable	Not effective	Sudden	Victims are reported to have suffered painful skin lesions, lightheadedness, dyspnea, and a rapid onset of hemorrhage, incapacitation and death. Survivors developed a radiation-like sickness including fever, nausea, vomiting, diarrhea, leukopenia, bleeding, and sepsis.	General supportive measures are used to alleviate acute T-2 toxicoses. Prompt (within 5-60 min of exposure) soap and water wash significantly reduces the development of the localized destructive, cutaneous effects of the toxin. After oral exposure management should include standard therapy for poison ingestion.	1. Sabotage 2. Aerosol

This appendix contains some CBR terms that do not actually appear in this manual. They have been included to present a comprehensive list that pertains to this series of publications.

CHEMICAL TERMS

A

Acetylcholinesterase. An enzyme that hydrolyzes the neurotransmitter acetylcholine. The action of this enzyme is inhibited by nerve agents.

Aerosol. Fine liquid or solid particles suspended in a gas (e.g., fog or smoke).

Atropine. A compound used as an antidote for nerve agents.

C

Casualty (toxic) agents. Produce incapacitation, serious injury, or death, and can be used to incapacitate or kill victims. They are the blister, blood, choking, and nerve agents.

> **Blister agents.** Substances that cause blistering of the skin. Exposure is through liquid or vapor contact with any exposed tissue (eyes, skin, lungs). Examples are distilled mustard (**HD**), nitrogen mustard (**HN**), lewisite (**L**), mustard/lewisite (**HL**), and phenodichloroarsine (**PD**).
>
> **Blood agents.** Substances that injure a person by interfering with cell respiration (the exchange of oxygen and carbon dioxide between blood and tissues). Examples are arsine (**SA**), cyanogens chloride (**CK**), hydrogen chloride (**HCl**), and hydrogen cyanide (**AC**).
>
> **Choking/lung/pulmonary agents.** Substances that cause physical injury to the lungs. Exposure is through inhalation. In extreme cases, membranes swell and

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  http://www.dca.state.fl.us/bpr/EMTOOLS/CIP/critical_infrastructure_protecti.htm

- George Washington University, Institute for Crisis, Disaster, and Risk Management
  http://www.cee.seas.gwu.edu
  or
  http://www.seas.gwu.edu/~icdm

- Homeland Protection Institute, Ltd.
  http://www.hpi-tech.org

- Inland Rivers Ports and Terminals
  http://www.irpt.net

- Institute of Electrical and Electronics Engineers, Inc. - USA
  http://www.ieeeusa.org or http://www.ieee.org/portal/index.jsp

- International Association of Foundation Drilling
  http://www.adsc-iafd.com

- International Code Council (ICC)
  http://www.intlcode.org
  Consolidates services, products, and operations of BOCA (Building Officials and Code Administrators), ICBO (International Conference of Building Officials) and SBCCI Southern Building Code Congress International) into one member service organization — the International Code Council (ICC) in January 2003.

- International Facility Management Association (IFMA)
  http://www.ifma.org

- Market Development Alliance of the FRP Composites Industry
  http://www.mdacomposites.org
- Multidisciplinary Center for Earthquake Engineering Research
  http://mceer.buffalo.edu
- National Aeronautics and Space Administration
  http://www.nasa.gov
- National Capital Planning Commission (NCPC)
  http://www.ncpc.gov
  - Security and Urban Design
    http://www.ncpc.gov/planning_init/security.html
- National Center for Manufacturing Sciences
  http://www.ncms.org
- National Concrete Masonry Association
  http://www.ncma.org
- National Conference of States on Building Codes and Standards
  http://www.ncsbcs.org
- National Council of Structural Engineers Associations (NCSEA)
  http://www.ncsea.com or http://dwp.bigplanet.com/engineers/homepage
- National Crime Prevention Institute
  http://www.louisville.edu/a-s/ja/ncpi/courses.htm
- National Fire Protection Association
  http://www.nfpa.org
- National Institute of Building Sciences (NIBS)
  http://www.nibs.org and http://www.wbdg.org
- National Park Service, Denver Service Center
  http://www.nps.gov/dsc
- National Precast Concrete Association
  http://www.precast.org

- National Wilderness Training Center, Inc.
  http://www.wildernesstraining.net
- New York City Office of Emergency Preparedness
  http://www.nyc.gov/html/oem
- Ohio State University
  http://www.osu.edu/homelandsecurity
- Pentagon Renovation Program
  http://renovation.pentagon.mil
- Portland Cement Association (PCA)
  http://www.portcement.org
- Primary Glass Manufacturers Council
  http://www.primaryglass.org
- Protective Glazing Council
  http://www.protectiveglazing.org
- Protective Technology Center at Penn State University
  http://www.ptc.psu.edu
- SAVE International
  http://www.value-eng.org
- Society of Fire Protection Engineers
  http://www.sfpe.org
- Southern Building Code Congress, International
  http://www.sbcci.org
- Sustainable Buildings Industry Council
  http://www.sbicouncil.org
- Transit Standards Consortium
  http://www.tsconsortium.org
- Transportation Research Board/Marine Board
  http://www.trb.org
- Transportation Security Administration - Maritime and Land
  http://www.tsa.dot.gov

- University of Missouri, Department of Civil & Environmental Engineering, National Center for Explosion Resistant Design
  http://www.engineering.missouri.edu/explosion.htm

- U.S. Air Force Civil Engineer Support Agency
  http://www.afcesa.af.mil

- U.S. Coast Guard
  http://www.uscg.mil

- U.S. Department of Energy
  http://www.energy.gov

  - Sandia National Laboratories (SNL)
    http://www.sandia.gov

  - Architectural Surety Program
    http://www.sandia.gov/archsur

  - Critical Infrastructure Protection Initiative
    http://www.sandia.gov/LabNews/LN02-11-00/steam_story.html

- U.S. Department of Health and Human Services
  http://www.hhs.gov

- U.S. Department of Veterans Affairs (VA)
  http://www.va.gov/facmgt

- U.S. Environmental Protection Agency (EPA), Chemical Emergency Preparedness and Prevention Office (CEPPO)–Counter-terrorism
  http://www.epa.gov/swercepp/cntr-ter.html

- U.S. General Services Administration (GSA)
  http://www.gsa.gov

  - Office of Federal Protective Service (FPS) of GSA
    http://www.gsa.gov/Portal/content/orgs_content.jsp?contentOID=117945&contentType=1005&P=1&S=1

  - Office of Public Building Service (PBS) of GSA
    http://www.gsa.gov/Portal/content/orgs_content.jsp?contentOID=22883&contentType=1005&PPzz=1&S=1

- Office of the Chief Architect of GSA
  http://www.gsa.gov/Portal/content/orgs_content.jsp?contentOID=22899&contentType=1005
  and
  http://www.oca.gsa.gov

❍ U.S. Green Building Council
http://www.usgbc.org

❍ U.S. Marine Corps Headquarters
http://www.usmc.mil

❍ U.S. Society on Dams
http://www.ussdams.org

❍ Virginia Polytechnic Institute and State University
http://www.ce.vt.edu

❍ Water and Wastewater Equipment Manufacturers Association
http://www.wwema.org

The Partnership for Critical Infrastructure (PCIS)

http://www.pcis.org

Note: Involved mainly with information systems and not building real property.

Government

❍ Department of Commerce Critical Infrastructure Assurance Office (CIAO)
http://www.ciao.gov

❍ Department of Energy (DOE)
http://www.energy.gov

❍ Department of Homeland Security
http://www.whitehouse.gov/deptofhomeland

❍ National Infrastructure Protection Center (NIPC)
http://www.nipc.gov

Private Sector

- Anser Institute for Homeland Security (ANSER)
  http://www.homelandsecurity.org
- CERT® Coordination Center (CERT/CC)
  http://www.cert.org
- Electronic Warfare Associates (EWA)
  http://www.ewa.com
- Information Technology Association of America (ITAA)
  http://www.itaa.org
- National Cyber Security Alliance (Alliance)
  http://www.staysafeonline.info
- North American Electric Reliability Council (NERC)
  http://www.nerc.com
- SANS Institute (SANS - SysAdmin, Audit, Network, Security)
  http://www.sans.org
- The Financial Services Roundtable Technology Group (BITS)
  http://www.bitsinfo.org
- The Institute for Internal Auditors (IIA)
  http://www.theiia.org
- The U.S. Chamber of Commerce, Center for Corporate Citizenship (CCC)
  http://www.uschamber.com/ccc

Selected States and Local Organizations

- Association of Metropolitan Water Agencies
  http://www.amwa.net
- International Association of Emergency Managers (IAEM)
  http://www.iaem.com
- National Association of State CIOs (NASCIO)
  http://www.nascio.org

- National Emergency Managers Association (NEMA)
  http://www.nemaweb.org
- National Governor's Association (NGA)
  http://www.csg.org
- The Council of State Governments (CSG)
  http://www.csg.org
- The National League of Cities (NLC)
  http://www.nlc.org

BUILDING VULNERABILITY ASSESSMENT CHECKLIST F

The Building Vulnerability Assessment Checklist is based on the checklist developed by the Department of Veterans Affairs (VA) and compiles many best practices based on technologies and scientific research to consider during the design of a new school building or renovation of an existing building. It allows a consistent security evaluation of designs at various levels. The checklist can be used as a screening tool for preliminary design vulnerability assessment or be used by subject matter experts for a comprehensive vulnerability assessment of existing buildings. In addition to examining design issues that affect vulnerability, the checklist includes questions that determine if critical systems continue to function in order to enhance deterrence, detection, denial, and damage limitation, and to ensure that emergency systems function during a threat or hazard situation.

The checklist is organized into the 13 sections listed below. To conduct a vulnerability assessment of a school building or preliminary design, each section of the checklist should be assigned to an engineer, architect, or subject matter expert who is knowledgeable and qualified to perform an assessment of the assigned area. Each assessor should consider the questions and guidance provided to help identify vulnerabilities and document results in the observations column. If assessing an existing building, vulnerabilities can also be documented with photographs, if possible. The results of the 13 assessments should be integrated into a master vulnerability assessment and provide a basis for determining vulnerability ratings during the assessment process.

1. Site
2. Architectural
3. Structural Systems
4. Building Envelope
5. Utility Systems
6. Mechanical Systems (heating, ventilation, and air conditioning (HVAC) and CBR)
7. Plumbing and Gas Systems
8. Electrical Systems
9. Fire Alarm Systems
10. Communications and Information Technology (IT) Systems
11. Equipment Operations and Maintenance
12. Security Systems
13. Security Master Plan

Building Vulnerablilty Assessment Checklist*

Section	Vulnerability Question	Guidance	Observations
1	**Site**		
1.1	**What major structures surround the facility (site or building(s))?** **What critical infrastructure, government, military, or recreation facilities are in the local area that impact transportation, utilities, and collateral damage (attack at this facility impacting the other major structures or attack on the major structures impacting this facility)?** **What are the adjacent land uses immediately outside the perimeter of this facility (site or building(s))?**	**Critical infrastructure to consider includes:** **Telecommunications infrastructure** Facilities for broadcast TV, cable TV; cellular networks; newspaper offices, production, and distribution; radio stations; satellite base stations; telephone trunking and switching stations, including critical cable routes and major rights-of-way **Electric power systems** Power plants, especially nuclear facilities; transmission and distribution system components; fuel distribution, delivery, and storage **Gas and oil facilities** Hazardous material facilities, oil/gas pipelines, and storage facilities	

Section	Vulnerability Question	Guidance	Observations
	Do future development plans change these land uses outside the facility (site or building (s)) perimeter? Although this question bridges threat and vulnerability, the threat is the manmade hazard that can occur (likelihood and impact) and the vulnerability is the proximity of the hazard to the building(s) being assessed. Thus, a chemical plant release may be a threat/hazard, but vulnerability changes if the plant is 1 mile upwind for the prevailing winds versus 10 miles away and downwind. Similarly, a terrorist attack upon an adjacent building may impact the building(s) being assessed. The Murrah Federal Building in Oklahoma City was not the only building to have severe damage caused by the explosion of the Ryder rental truck bomb.	**Banking and finance institutions** Financial institutions (banks, credit unions) and the business district; note schedule business/financial district may follow; armored car services **Transportation networks** Airports: carriers, flight paths, and airport layout; location of air traffic control towers, runways, passenger terminals, and parking areas Bus Stations Pipelines: oil; gas Trains/Subways: rails and lines, railheads/rail yards, interchanges, tunnels, and cargo/passenger terminals; note hazardous material transported Traffic: interstate highways/roads/tunnels/bridges carrying large volumes; points of congestion; note time of day and day of week Trucking: hazardous materials cargo loading/ unloading facilities; truck terminals, weigh stations, and rest areas Waterways: dams; levees; berths and ports for cruise ships, ferries, roll-on/roll-off cargo vessels, and container ships; international (foreign) flagged vessels (and cargo) **Water supply systems** Pipelines and process/treatment facilities, dams for water collection; wastewater treatment **Government services** Federal/state/local government offices – post offices, law enforcement stations, fire/rescue, town/city hall, local mayor's/governor's residences, judicial offices and courts, military installations (include type-Active, Reserves, National Guard) **Emergency services** Backup facilities, communications centers, Emergency Operations Centers (EOCs), fire/ Emergency Medical Service (EMS) facilities, Emergency Medical Center (EMCs), law enforcement facilities	

Section	Vulnerability Question	Guidance	Observations
		The following are not critical infrastructure, but have potential collateral damage to consider: **Agricultural facilities:** chemical distribution, storage, and application sites; crop spraying services; farms and ranches; food processing, storage, and distribution facilities **Commercial/manufacturing/industrial facilities:** apartment buildings; business/corporate centers; chemical plants (especially those with Section 302 Extremely Hazardous Substances); factories; fuel production, distribution, and storage facilities; hotels and convention centers; industrial plants; raw material production, distribution, and storage facilities; research facilities and laboratories; shipping, warehousing, transfer, and logistical centers **Events and attractions:** festivals and celebrations; open-air markets; parades; rallies, demonstrations, and marches; religious services; scenic tours; theme parks **Health care system components:** family planning clinics; health department offices; hospitals; radiological material and medical waste transportation, storage, and disposal; research facilities and laboratories, walk-in clinics **Political or symbolically significant sites:** embassies, consulates, landmarks, monuments, political party and special interest groups offices, religious sites **Public/private institutions:** academic institutions, cultural centers, libraries, museums, research facilities and laboratories, schools **Recreation facilities:** auditoriums, casinos, concert halls and pavilions, parks, restaurants and clubs (frequented by potential target populations), sports arenas, stadiums, theaters, malls, and special interest group facilities; note congestion dates and times for shopping centers References: *FEMA 386-7, FEMA SLG 101, DOJ NCJ181200*	
1.2	**Does the terrain place the building in a depression or low area?**	Depressions or low areas can trap heavy vapors, inhibit natural decontamination by prevailing winds, and reduce the effectiveness of in-place sheltering. Reference: *USAF Installation Force Protection Guide*	

Section	Vulnerability Question	Guidance	Observations
1.3	**In dense, urban areas, does curb lane parking allow uncontrolled vehicles to park unacceptably close to a building in public rights-of-way?**	Where distance from the building to the nearest curb provides insufficient setback, restrict parking in the curb lane. For typical city streets, this may require negotiating to close the curb lane. Setback is common terminology for the distance between a building and its associated roadway or parking. It is analogous to stand-off between a vehicle bomb and the building. The benefit per foot of increased stand-off between a potential vehicle bomb and a building is very high when close to a building and decreases rapidly as the distance increases. Note that the July 1, 1994, Americans with Disabilities Act Standards for Accessible Design states that required handicapped parking shall be located on the shortest accessible route of travel from adjacent parking to an accessible entrance. Reference: *GSA PBS-P100*	
1.4	**Is a perimeter fence or other types of barrier controls in place?**	The intent is to channel pedestrian traffic onto a site with multiple buildings through known access control points. For a single building, the intent is to have a single visitor entrance. Reference: *GSA PBS-P100*	
1.5	**What are the site access points to the site or building?**	The goal is to have at least two access points – one for passenger vehicles and one for delivery trucks due to the different procedures needed for each. Having two access points also helps if one of the access points becomes unusable, then traffic can be routed through the other access point. Reference: *USAF Installation Force Protection Guide*	
1.6	**Is vehicle traffic separated from pedestrian traffic on the site?**	Pedestrian access should not be endangered by car traffic. Pedestrian access, especially from public transportation, should not cross vehicle traffic if possible. References: *GSA PBS-P100 and FEMA 386-7*	
1.7	**Is there vehicle and pedestrian access control at the perimeter of the site?**	Vehicle and pedestrian access control and inspection should occur as far from facilities as possible (preferably at the site perimeter) with the ability to regulate the flow of people and vehicles one at a time. Control on-site parking with identification checks, security personnel, and access control systems. Reference: *FEMA 386-7*	

Section	Vulnerability Question	Guidance	Observations
1.8	**Is there space for inspection at the curb line or outside the protected perimeter?** **What is the minimum distance from the inspection location to the building?**	Design features for the vehicular inspection point include: vehicle arrest devices that prevent vehicles from leaving the vehicular inspection area and prevent tailgating. If screening space cannot be provided, consider other design features such as: hardening and alternative location for vehicle search/inspection. Reference: *GSA PBS-P100*	
1.9	**Is there any potential access to the site or building through utility paths or water runoff?**	Eliminate potential site access through utility tunnels, corridors, manholes, stormwater runoff culverts, etc. Ensure covers to these access points are secured. Reference: *USAF Installation Force Protection Guide*	
1.10	**What are the existing types of vehicle anti-ram devices for the site or building?** **Are these devices at the property boundary or at the building?**	Passive barriers include bollards, walls, hardened fences (steel cable interlaced), trenches, ponds/basins, concrete planters, street furniture, plantings, trees, sculptures, and fountains. Active barriers include pop-up bollards, swing arm gates, and rotating plates and drums, etc. Reference: *GSA PBS-P100*	
1.11	**What is the anti-ram buffer zone stand-off distance from the building to unscreened vehicles or parking?**	If the recommended distance for the postulated threat is not available, consider reducing the stand-off required through structural hardening or manufacturing additional stand-off through barriers and parking restrictions. Also, consider relocation of vulnerable functions within the building, or to a more hazard-resistant building. More stand-off should be used for unscreened vehicles than for screened vehicles that have been searched. Reference: *GSA PBS-P100*	
1.12	**Are perimeter barriers capable of stopping vehicles?** **Will the vehicle barriers at the perimeter and building maintain access for emergency responders, including large fire apparatus?**	Anti-ram protection may be provided by adequately designed: bollards, street furniture, sculpture, landscaping, walls, and fences. The anti-ram protection must be able to stop the threat vehicle size (weight) at the speed attainable by that vehicle at impact. If the anti-ram protection cannot absorb the desired kinetic energy, consider adding speed controls (serpentines or speed bumps) to limit the speed at impact. If the resultant speed is still too great, the anti-ram protection should be improved. References: *Military Handbook 1013/14 and GSA PBS P-100*	

Section	Vulnerability Question	Guidance	Observations
1.13	**Does site circulation prevent high-speed approaches by vehicles?**	The intent is to use site circulation to minimize vehicle speeds and eliminate direct approaches to structures. Reference: *GSA PBS-P100*	
1.14	**Are there offsetting vehicle entrances from the direction of a vehicle's approach to force a reduction of speed?**	Single or double 90-degree turns effectively reduce vehicle approach speed. Reference: *GSA PBS-P100*	
1.15	**Is there a minimum setback distance between the building and parked vehicles?**	Adjacent public parking should be directed to more distant or better-protected areas, segregated from employee parking and away from the building. Some publications use the term setback in lieu of the term stand-off. Reference: *GSA PBS-P100*	
1.16	**Does adjacent surface parking on site maintain a minimum stand-off distance?**	The specific stand-off distance needed is based upon the design basis threat bomb size and the building construction. For initial screening, consider using 25 meters (82 feet) as a minimum, with more distance needed for unreinforced masonry or wooden walls. Reference: *GSA PBS-P100*	
1.17	**Do standalone, aboveground parking garages provide adequate visibility across as well as into and out of the parking garage?**	Pedestrian paths should be planned to concentrate activity to the extent possible. Limiting vehicular entry/exits to a minimum number of locations is beneficial. Stair tower and elevator lobby design should be as open as code permits. Stair and/or elevator waiting areas should be as open to the exterior and/or the parking areas as possible and well lighted. Impact-resistant, laminated glass for stair towers and elevators is a way to provide visual openness. Potential hiding places below stairs should be closed off; nooks and crannies should be avoided, and dead-end parking areas should be eliminated. Reference: *GSA PBS-P100*	
1.18	**Are garage or service area entrances for employee-permitted vehicles protected by suitable anti-ram devices?** **Coordinate this protection with other anti-ram devices, such as on the perimeter or property boundary to avoid duplication of arresting capability.**	Control internal building parking, underground parking garages, and access to service areas and loading docks in this manner with proper access control, or eliminate the parking altogether. The anti-ram device must be capable of arresting a vehicle of the designated threat size at the speed attainable at the location. Reference: *GSA PBS-P100*	

Section	Vulnerability Question	Guidance	Observations
1.19	**Do site landscaping and street furniture provide hiding places?**	Minimize concealment opportunities by keeping landscape plantings (hedges, shrubbery, and large plants with heavy ground cover) and street furniture (bus shelters, benches, trash receptacles, mailboxes, newspaper vending machines) away from the building to permit observation of intruders and prevent hiding of packages. If mail or express boxes are used, the size of the openings should be restricted to prohibit the insertion of packages. Reference: *GSA PBS-P100*	
1.20	**Is the site lighting adequate from a security perspective in roadway access and parking areas?**	Security protection can be successfully addressed through adequate lighting. The type and design of lighting, including illumination levels, is critical. Illuminating Engineering Society of North America (IESNA) guidelines can be used. The site lighting should be coordinated with the CCTV system. Reference: *GSA PBS-P100*	
1.21	**Are line-of-sight perspectives from outside the secured boundary to the building and on the property along pedestrian and vehicle routes integrated with landscaping and green space?**	The goal is to prevent the observation of critical assets by persons outside the secure boundary of the site. For individual buildings in an urban environment, this could mean appropriate window treatments or no windows for portions of the building. Once on the site, the concern is to ensure observation by a general workforce aware of any pedestrians or vehicles outside normal circulation routes or attempting to approach the building unobserved. Reference: *USAF Installation Force Protection Guide*	
1.22	**Do signs provide control of vehicles and people?**	The signage should be simple and have the necessary level of clarity. However, signs that identify sensitive areas should generally not be provided. Reference: *GSA PBS-P100*	
1.23	**Are all existing fire hydrants on the site accessible?**	Just as vehicle access points to the site must be able to transit emergency vehicles, so too must the emergency vehicles have access to the buildings and, in the case of fire trucks, the fire hydrants. Thus, security considerations must accommodate emergency response requirements. Reference: *GSA PBS-P100*	

Section	Vulnerability Question	Guidance	Observations
2	**Architectural**		
2.1	**Does the site and architectural design incorporate strategies from a Crime Prevention Through Environmental Design (CPTED) perspective?**	**The focus of CPTED is on creating defensible space by employing:** **1. Natural access controls:** – Design streets, sidewalks, and building entrances to clearly indicate public routes and direct people away from private/restricted areas – Discourage access to private areas with structural elements and limit access (no cut-through streets) – Loading zones should be separate from public parking **2. Natural surveillance:** – Design that maximizes visibility of people, parking areas, and building entrances; doors and windows that look out on to streets and parking areas – Shrubbery under 2 feet in height for visibility – Lower branches of existing trees kept at least 10 feet off the ground – Pedestrian-friendly sidewalks and streets to control pedestrian and vehicle circulation – Adequate nighttime lighting, especially at exterior doorways **3. Territorial reinforcement:** – Design that defines property lines – Design that distinguishes private/restricted spaces from public spaces using separation, landscape plantings; pavement designs (pathway and roadway placement); gateway treatments at lobbies, corridors, and door placement; walls, barriers, signage, lighting, and "CPTED" fences – "Traffic-calming" devices for vehicle speed control **4. Target hardening:** – Prohibit entry or access: window locks, deadbolts for doors, interior door hinges – Access control (building and employee/visitor parking) and intrusion detection systems **5. Closed circuit television cameras:** – Prevent crime and influence positive behavior, while enhancing the intended uses of space. In other words, design that eliminates or reduces criminal behavior and at the same time encourages people to "keep an eye out" for each other. References: *GSA PBS-P100 and FEMA 386-7*	

Section	Vulnerability Question	Guidance	Observations
2.2	**Is it a mixed-tenant building?**	Separate high-risk tenants from low-risk tenants and from publicly accessible areas. Mixed uses may be accommodated through such means as separating entryways, controlling access, and hardening shared partitions, as well as through special security operational countermeasures. Reference: *GSA PBS-P100*	
2.3	**Are pedestrian paths planned to concentrate activity to aid in detection?**	Site planning and landscape design can provide natural surveillance by concentrating pedestrian activity, limiting entrances/exits, and eliminating concealment opportunities. Also, prevent pedestrian access to parking areas other than via established entrances. Reference: *GSA PBS-P100*	
2.4	**Are there trash receptacles and mailboxes in close proximity to the building that can be used to hide explosive devices?**	The size of the trash receptacles and mailbox openings should be restricted to prohibit insertion of packages. Street furniture, such as newspaper vending machines, should be kept sufficient distance (10 meters or 33 feet) from the building, or brought inside to a secure area. References: *USAF Installation Force Protection Guide and DoD UCF 4-010-01*	
2.5	**Do entrances avoid significant queuing?**	If queuing will occur within the building footprint, the area should be enclosed in blast-resistant construction. If queuing is expected outside the building, a rain cover should be provided. For manpower and equipment requirements, collocate or combine staff and visitor entrances. Reference: *GSA PBS-P100*	
2.6	**Does security screening cover all public and private areas?** **Are public and private activities separated?** **Are public toilets, service spaces, or access to stairs or elevators located in any non-secure areas, including the queuing area before screening at the public entrance?**	Retail activities should be prohibited in non-secured areas. However, the Public Building Cooperative Use Act of 1976 encourages retail and mixed uses to create open and inviting buildings. Consider separating entryways, controlling access, hardening shared partitions, and special security operational countermeasures. References: *GSA PBS-P100 and FEMA 386-7*	

Section	Vulnerability Question	Guidance	Observations
2.7	**Is access control provided through main entrance points for employees and visitors?** (lobby receptionist, sign-in, staff escorts, issue of visitor badges, checking forms of personal identification, electronic access control systems)	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
2.8	**Is access to private and public space or restricted area space clearly defined through the design of the space, signage, use of electronic security devices, etc.?**	Finishes and signage should be designed for visual simplicity. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
2.9	**Is access to elevators distinguished as to those that are designated only for employees and visitors?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
2.10	**Do public and employee entrances include space for possible future installation of access control and screening equipment?**	These include walk-through metal detectors and x-ray devices, identification check, electronic access card, search stations, and turnstiles. Reference: *GSA PBS-P100*	
2.11	**Do foyers have reinforced concrete walls and offset interior and exterior doors from each other?**	Consider for exterior entrances to the building or to access critical areas within the building if explosive blast hazard must be mitigated. Reference: *U.S. Army TM 5-853*	
2.12	**Do doors and walls along the line of security screening meet requirements of UL752 "Standard for Safety: Bullet-Resisting Equipment"?**	If the postulated threat in designing entrance access control includes rifles, pistols, or shotguns, then the screening area should have bullet-resistance to protect security personnel and uninvolved bystanders. Glass, if present, should also be bullet-resistant. Reference: *GSA PBS-P100*	
2.13	**Do circulation routes have unobstructed views of people approaching controlled access points?**	This applies to building entrances and to critical areas within the building. References: *USAF Installation Force Protection Guide and DoD UFC 4-010-01*	

Section	Vulnerability Question	Guidance	Observations
2.14	**Is roof access limited to authorized personnel by means of locking mechanisms?**	References: *GSA PBS-P100 and CDC/NIOSH, Pub 2002-139*	
2.15	**Are critical assets (people, activities, building systems and components) located close to any main entrance, vehicle circulation, parking, maintenance area, loading dock, or interior parking?** **Are the critical building systems and components hardened?**	Critical building components include: Emergency generator including fuel systems, day tank, fire sprinkler, and water supply; Normal fuel storage; Main switchgear; Telephone distribution and main switchgear; Fire pumps; Building control centers; Uninterruptible Power Supply (UPS) systems controlling critical functions; Main refrigeration and ventilation systems if critical to building operation; Elevator machinery and controls; Shafts for stairs, elevators, and utilities; Critical distribution feeders for emergency power. Evacuation and rescue require emergency systems to remain operational during a disaster and they should be located away from potential attack locations. Primary and backup systems should be separated to reduce the risk of both being impacted by a single incident if collocated. Utility systems should be located at least 50 feet from loading docks, front entrances, and parking areas. One way to harden critical building systems and components is to enclose them within hardened walls, floors, and ceilings. Do not place them near high-risk areas where they can receive collateral damage. Reference: *GSA PBS-P100*	
2.16	**Are high-value or critical assets located as far into the interior of the building as possible and separated from the public areas of the building?**	Critical assets, such as people and activities, are more vulnerable to hazards when on an exterior building wall or adjacent to uncontrolled public areas inside the building. Reference: *GSA PBS-P100*	
2.17	**Is high visitor activity away from critical assets?**	High-risk activities should also be separated from low-risk activities. Also, visitor activities should be separated from daily activities. Reference: *USAF Installation Force Protection Guide*	
2.18	**Are critical assets located in spaces that are occupied 24 hours per day?** **Are assets located in areas where they are visible to more than one person?**	Reference: *USAF Installation Force Protection Guide*	

Section	Vulnerability Question	Guidance	Observations
2.19	**Are loading docks and receiving and shipping areas separated in any direction from utility rooms, utility mains, and service entrances, including electrical, telephone/data, fire detection/ alarm systems, fire suppression water mains, cooling and heating**	Loading docks should be designed to keep vehicles from driving into or parking under the building. If loading docks are in close proximity to critical equipment, consider hardening the equipment and service against explosive blast. Consider a 50-foot separation distance in all directions. Reference: *GSA PBS-P100*	
2.20	**Are mailrooms located away from building main entrances, areas containing critical services, utilities, distribution systems, and important assets?** **Is the mailroom located near the loading dock?**	The mailroom should be located at the perimeter of the building with an outside wall or window designed for pressure relief. By separating the mailroom and the loading dock, the collateral damage of an incident at one has less impact upon the other. However, this may be the preferred mailroom location. Off-site screening stations or a separate delivery processing building on site may be cost-effective, particularly if several buildings may share one mailroom. A separate delivery processing building reduces risk and simplifies protection measures. Reference: *GSA PBS-P100*	
2.21	**Does the mailroom have adequate space available for equipment to examine incoming packages and for an explosive disposal**	Screening of all deliveries to the building, including U.S. mail, commercial package delivery services, delivery of office supplies, etc. Reference: *GSA PBS-P100*	
2.22	**Are areas of refuge identified, with special consideration given to egress?**	Areas of refuge can be safe havens, shelters, or protected spaces for use during specified hazards. Reference: *FEMA 386-7*	
2.23	**Are stairwells required for emergency egress located as remotely as possible from high-risk areas where blast events might occur?** **Are stairways maintained with positive pressure or are there other smoke control systems?**	Consider designing stairs so that they discharge into areas other than lobbies, parking, or loading docks. Maintaining positive pressure from a clean source of air (may require special filtering) aids in egress by keeping smoke, heat, toxic fumes, etc,. out of the stairway. Pressurize exit stairways in accordance with the National Model Building Code. References: *GSA PBS-P100 and CDC/NIOSH, Pub 2002-139*	

Section	Vulnerability Question	Guidance	Observations
2.24	**Are enclosures for emergency egress hardened to limit the extent of debris that might otherwise impede safe passage and reduce the flow of evacuees?**	Egress pathways should be hardened and discharge into safe areas. Reference: *FEMA 386-7*	
2.25	**Do interior barriers differentiate level of security within a building?**	Reference: *USAF Installation Force Protection Guide*	
2.26	**Are emergency systems located away from high-risk areas?**	The intent is to keep the emergency systems out of harm's way, such that one incident does not take out all capability – both the regular systems and their backups. Reference: *FEMA 386-7*	
2.27	**Is interior glazing near high-risk areas minimized?** **Is interior glazing in other areas shatter-resistant?**	Interior glazing should be minimized where a threat exists and should be avoided in enclosures of critical functions next to high-risk areas. Reference: *GSA PBS-P100*	
2.28	**Are ceiling and lighting systems designed to remain in place during hazard events?**	When an explosive blast shatters a window, the blast wave enters the interior space, putting structural and non-structural building components under loads not considered in standard building codes. It has been shown that connection criteria for these systems in high seismic activity areas resulted in much less falling debris that could injure building occupants. Mount all overhead utilities and other fixtures weighing 14 kilograms (31 pounds) or more to minimize the likelihood that they will fall and injure building occupants. Design all equipment mountings to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction. This standard does not preclude the need to design equipment mountings for forces required by other criteria, such as seismic standards. Reference: *DoD UCF 4-101-01*	

Section	Vulnerability Question	Guidance	Observations
3	**Structural Systems**		
3.1	**What type of construction?** **What type of concrete and reinforcing steel?** **What type of steel?** **What type of foundation?**	The type of construction provides an indication of the robustness to abnormal loading and load reversals. A reinforced concrete moment-resisting frame provides greater ductility and redundancy than a flat-slab or flat-plate construction. The ductility of steel frame with metal deck depends on the connection details and pre-tensioned or post-tensioned construction provides little capacity for abnormal loading patterns and load reversals. The resistance of load-bearing wall structures varies to a great extent, depending on whether the walls are reinforced or un-reinforced. A rapid screening process developed by FEMA for assessing structural hazards identifies the following types of construction with a structural score ranging from 1.0 to 8.5. A higher score indicates a greater capacity to sustain load reversals. Wood buildings of all types - 4.5 to 8.5 Steel moment-resisting frames - 3.5 to 4.5 Braced steel frames - 2.5 to 3.0 Light metal buildings - 5.5 to 6.5 Steel frames with cast-in-place concrete shear walls - 3.5 to 4.5 Steel frames with unreinforced masonry infill walls - 1.5 to 3.0 Concrete moment-resisting frames - 2.0 to 4.0 Concrete shear wall buildings - 3.0 to 4.0 Concrete frames with unreinforced masonry infill walls - 1.5 to 3.0 Tilt-up buildings - 2.0 to 3.5 Precast concrete frame buildings - 1.5 to 2.5 Reinforced masonry - 3.0 to 4.0 Unreinforced masonry - 1.0 to 2.5 References: *FEMA 154 and Physical Security Assessment for the Department of Veterans Affairs Facilities*	
3.2	**Do the reinforced concrete structures contain symmetric steel reinforcement (positive and negative faces) in all floor slabs, roof slabs, walls, beams, and girders that may be subjected to rebound, uplift, and suction pressures?**	Reference: *GSA PBS-P100*	

Section	Vulnerability Question	Guidance	Observations
	Do the lap splices fully develop the capacity of the reinforcement? **Are lap splices and other discontinuities staggered?** **Do the connections possess ductile details?** **Is special shear reinforcement, including ties and stirrups, available to allow large post-elastic behavior?**		
3.3	**Are the steel frame connections moment connections?** **Is the column spacing minimized so that reasonably sized members will resist the design loads and increase the redundancy of the system?** **What are the floor-to-floor heights?**	A practical upper level for column spacing is generally 30 feet. Unless there is an overriding architectural requirement, a practical limit for floor-to-floor heights is generally less than or equal to 16 feet. Reference: *GSA PBS-P100*	
3.4	**Are critical elements vulnerable to failure?**	The priority for upgrades should be based on the relative importance of structural or non-structural elements that are essential to mitigating the extent of collapse and minimizing injury and damage. Primary Structural Elements provide the essential parts of the building's resistance to catastrophic blast loads and progressive collapse. These include columns, girders, roof beams, and the main lateral resistance system. Secondary Structural Elements consist of all other load-bearing members, such as floor beams, slabs, etc. Primary Non-Structural Elements consist of elements (including their attachments) that are essential for life safety systems or elements that can cause substantial injury if failure occurs, including ceilings or heavy suspended mechanical units. Secondary Non-Structural Elements consist of all elements not covered in primary non-structural elements, such as partitions, furniture, and light fixtures. Reference: *GSA PBS-P100*	

Section	Vulnerability Question	Guidance	Observations
3.5	**Will the structure suffer an unacceptable level of damage resulting from the postulated threat (blast loading or weapon impact)?**	The extent of damage to the structure and exterior wall systems from the bomb threat may be related to a protection level. The following is for new buildings: **Level of Protection Below Antiterrorism Standards –** Severe damage. Frame collapse/massive destruction. Little left standing. Doors and windows fail and result in lethal hazards. Majority of personnel suffer fatalities. **Very Low Level Protection –** Heavy damage. Onset of structural collapse. Major deformation of primary and secondary structural members, but progressive collapse is unlikely. Collapse of non-structural elements. Glazing will break and is likely to be propelled into the building, resulting in serious glazing fragment injuries, but fragments will be reduced. Doors may be propelled into rooms, presenting serious hazards. Majority of personnel suffer serious injuries. There are likely to be a limited number (10 percent to 25 percent) of fatalities. **Low Level of Protection –** Moderate damage, unrepairable. Major deformation of non-structural elements and secondary structural members and minor deformation of primary structural members, but progressive collapse is unlikely. Glazing will break, but fall within 1 meter of the wall or otherwise not present a significant fragment hazard. Doors may fail, but they will rebound out of their frames, presenting minimal hazards. Majority of personnel suffer significant injuries. There may be a few (<10 percent) fatalities. **Medium Level Protection –** Minor damage, repairable. Minor deformations of non-structural elements and secondary structural members and no permanent deformation in primary structural members. Glazing will break, but will remain in the window frame. Doors will stay in frames, but will not be reusable. Some minor injuries, but fatalities are unlikely. **High Level Protection –** Minimal damage, repairable. No permanent deformation of primary and secondary structural members or non-structural elements. Glazing will not break. Doors will be reusable. Only superficial injuries are likely. Reference: *DoD UFC 4-010-01*	
3.6	**Is the structure vulnerable to progressive collapse?** **Is the building capable of sustaining the removal of a column for one floor above grade at**	Design to mitigate progressive collapse is an independent analysis to determine a system's ability to resist structural collapse upon the loss of a major structural element or the system's ability to resist the loss of a major structural element. Design to mitigate progressive collapse may be based on the methods outlined in ASCE 7-98 (now 7-02). Designers may apply static and/or	

Section	Vulnerability Question	Guidance	Observations
	the building perimeter without progressive collapse? **In the event of an internal explosion in an uncontrolled public ground floor area, does the design prevent progressive collapse due to the loss of one primary column?** **Do architectural or structural features provide a minimum 6-inch stand-off to the internal columns (primary vertical load carrying members)?** **Are the columns in the unscreened internal spaces designed for an unbraced length equal to two floors, or three floors where there are two levels of parking?**	dynamic methods of analysis to meet this requirement and ultimate load capacities may be assumed in the analyses. Combine structural upgrades for retrofits to existing buildings, such as seismic and progressive collapse, into a single project due to the economic synergies and other cross benefits. Existing facilities may be retrofitted to withstand the design level threat or to accept the loss of a column for one floor above grade at the building perimeter without progressive collapse. Note that collapse of floors or roof must not be permitted. Reference: *GSA PBS-P100*	
3.7	**Are there adequate redundant load paths in the structure?**	Special consideration should be given to materials that have inherent ductility and that are better able to respond to load reversals, such as cast in place reinforced concrete, reinforced masonry, and steel construction. Careful detailing is required for material such as pre-stressed concrete, pre-cast concrete, and masonry to adequately respond to the design loads. Primary vertical load carrying members should be protected where parking is inside a facility and the building superstructure is supported by the parking structure. Reference: *GSA PBS-P100*	
3.8	**Are there transfer girders supported by columns within unscreened public spaces or at the exterior of the building?**	Transfer girders allow discontinuities in columns between the roof and foundation. This design has inherent difficulty in transferring load to redundant paths upon loss of a column or the girder. Transfer beams and girders that, if lost, may cause progressive collapse are highly discouraged. Reference: *GSA PBS-P100*	
3.9	**What is the grouting and reinforcement of masonry (brick and/or concrete masonry unit (CMU)) exterior walls?**	Avoid unreinforced masonry exterior walls. Reinforcement can run the range of light to heavy, depending upon the stand-off distance available and postulated design threat. Reference: *GSA PBS-P100* recommends fully grouted and reinforced CMU construction where CMU is selected.	

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		Reference: *DoD Minimum Antiterrorism Standards for Buildings* states "Unreinforced masonry walls are prohibited for the exterior walls of new buildings. A minimum of 0.05 percent vertical reinforcement with a maximum spacing of 1200 mm (48 in) will be provided. For existing buildings, implement mitigating measures to provide an equivalent level of protection." [This is light reinforcement and based upon the recommended stand-off distance for the situation.]	
3.10	**Will the loading dock design limit damage to adjacent areas and vent explosive force to the exterior of the building?**	Design the floor of the loading dock for blast resistance if the area below is occupied or contains critical utilities. Reference: *GSA PBS-P100*	
3.11	**Are mailrooms, where packages are received and opened for inspection, and unscreened retail spaces designed to mitigate the effects of a blast on primary vertical or lateral bracing members?**	Where mailrooms and unscreened retail spaces are located in occupied areas or adjacent to critical utilities, walls, ceilings, and floors, they should be blast- and fragment- resistant. Methods to facilitate the venting of explosive forces and gases from the interior spaces to the outside of the structure may include blow-out panels and window system designs that provide protection from blast pressure applied to the outside, but that readily fail and vent if exposed to blast pressure on the inside. Reference: *GSA PBS-P100*	
4	**Building Envelope**		
4.1	**What is the designed or estimated protection level of the exterior walls against the postulated explosive threat?**	The performance of the façade varies to a great extent on the materials. Different construction includes brick or stone with block backup, steel stud walls, precast panels, or curtain wall with glass, stone, or metal panel elements. Shear walls that are essential to the lateral and vertical load bearing system and that also function as exterior walls should be considered primary structures and should resist the actual blast loads predicted from the threats specified. Where exterior walls are not designed for the full design loads, special consideration should be given to construction types that reduce the potential for injury. Reference: *GSA PBS-P100*	

Section	Vulnerability Question	Guidance	Observations
4.2	**Is there less than a 40 percent fenestration opening per structural bay?** **Is the window system design on the exterior façade balanced to mitigate the hazardous effects of flying glazing following an explosive event? (glazing, frames, anchorage to supporting walls, etc.)** **Do the glazing systems with a ½-inch (¾-inch is better) bite contain an application of structural silicone?** **Is the glazing laminated or is it protected with an anti-shatter (fragment retention) film?** **If an anti-shatter film is used, is it a minimum of a 7-mil thick film, or specially manufactured 4-mil thick film?**	The performance of the glass will similarly depend on the materials. Glazing may be single pane or double pane, monolithic or laminated, annealed, heat strengthened or fully tempered. The percent fenestration is a balance between protection level, cost, the architectural look of the building within its surroundings, and building codes. One goal is to keep fenestration to below 40 percent of the building envelope vertical surface area, but the process must balance differing requirements. A blast engineer may prefer no windows; an architect may favor window curtain walls; building codes require so much fenestration per square footage of floor area; fire codes require a prescribed window opening area if the window is a designated escape route; and the building owner has cost concerns. Ideally, an owner would want 100 percent of the glazed area to provide the design protection level against the postulated explosive threat (design basis threat– weapon size at the expected stand-off distance). However, economics and geometry may allow 80 percent to 90 percent due to the statistical differences in the manufacturing process for glass or the angle of incidence of the blast wave upon upper story windows (4th floor and higher). Reference: *GSA PBS-P100*	
4.3	**Do the walls, anchorage, and window framing fully develop the capacity of the glazing material selected?** **Are the walls capable of withstanding the dynamic reactions from the windows?** **Will the anchorage remain attached to the walls of the building during an explosive event without failure?** **Is the façade connected to backup block or to the structural frame?** **Are non-bearing masonry walls reinforced?**	Government produced and sponsored computer programs coupled with test data and recognized dynamic structural analysis techniques may be used to determine whether the glazing either survives the specified threats or the post damage performance of the glazing protects the occupants. A breakage probability no higher than 750 breaks per 1,000 may be used when calculating loads to frames and anchorage. The intent is to ensure the building envelope provides relatively equal protection against the postulated explosive threat for the walls and window systems for the safety of the occupants, especially in rooms with exterior walls. Reference: *GSA PBS-P100*	
4.4	**Does the building contain ballistic glazing?**	Glass-clad polycarbonate or laminated polycarbonate are two types of acceptable glazing material.	

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	Does the ballistic glazing meet the requirements of UL 752 Bullet-Resistant Glazing? **Does the building contain security-glazing?** **Does the security-glazing meet the requirements of ASTM F1233 or UL 972, Burglary Resistant Glazing Material?** **Do the window assemblies containing forced entry resistant glazing (excluding the glazing) meet the requirements of ASTM F 588?**	If windows are upgraded to bullet-resistant, burglar-resistant, or forced entry-resistant, ensure that doors, ceilings, and floors, as applicable, can resist the same for the areas of concern. Reference: *GSA PBS-P100*	
4.5	**Do non-window openings, such as mechanical vents and exposed plenums, provide the same level of protection required for the exterior wall?**	In-filling of blast over-pressures must be considered through non-window openings such that structural members and all mechanical system mountings and attachments should resist these interior fill pressures. These non-window openings should also be as secure as the rest of the building envelope against forced entry. Reference: *GSA PBS-P100*	
5	**Utility Systems**		
5.1	**What is the source of domestic water? (utility, municipal, wells, lake, river, storage tank)** **Is there a secure alternate drinking water supply?**	Domestic water is critical for continued building operation. Although bottled water can satisfy requirements for drinking water and minimal sanitation, domestic water meets many other needs – flushing toilets, building heating and cooling system operation, cooling of emergency generators, humidification, etc. Reference: *FEMA 386-7*	
5.2	**Are there multiple entry points for the water supply?**	If the building or site has only one source of water entering at one location, the entry point should be secure. Reference: *GSA PBS-P100*	
5.3	**Is the incoming water supply in a secure location?**	Ensure that only authorized personnel have access to the water supply and its components. Reference: *FEMA 386-7*	
5.4	**Does the building or site have storage capacity for domestic water?**	Operational facilities will require reliance on adequate domestic water supply. Storage capacity can meet short-term needs and use water trucks to replenish for extended outages.	

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	How many gallons of storage capacity are available and how long will it allow operations to continue?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities.*	
5.5	**What is the source of water for the fire suppression system? (local utility company lines, storage tanks with utility company backup, lake, or river)** **Are there alternate water supplies for fire suppression?**	The fire suppression system water may be supplied from the domestic water or it may have a separate source, separate storage, or nonpotable alternate sources. For a site with multiple buildings, the concern is that the supply should be adequate to fight the worst case situation according to the fire codes. Recent major construction may change that requirement. Reference: *FEMA 386-7*	
5.6	**Is the fire suppression system adequate, code-compliant, and protected (secure location)?**	Standpipes, water supply control valves, and other system components should be secure or supervised. Reference: *FEMA 386-7*	
5.7	**Do the sprinkler/standpipe interior controls (risers) have fire- and blast-resistant separation?** **Are the sprinkler and standpipe connections adequate and redundant?** **Are there fire hydrant and water supply connections near the sprinkler/standpipe connections?**	The incoming fire protection water line should be encased, buried, or located 50 feet from high-risk areas. The interior mains should be looped and sectionalized. Reference: *GSA PBS-P100*	
5.8	**Are there redundant fire water pumps (e.g., one electric, one diesel)?** **Are the pumps located apart from each other?**	Collocating fire water pumps puts them at risk for a single incident to disable the fire suppression system. References: *GSA PBS-P100 and FEMA 386-7*	
5.9	**Are sewer systems accessible?** **Are they protected or secured?**	Sanitary and stormwater sewers should be protected from unauthorized access. The main concerns are backup or flooding into the building, causing a health risk, shorting out electrical equipment, and loss of building use. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.10	**What fuel supplies do the building rely upon for critical operation?**	Typically, natural gas, propane, or fuel oil are required for continued operation. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

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5.11	**How much fuel is stored on the site or at the building and how long can this quantity support critical operations?** **How is it stored?** **How is it secured?**	Fuel storage protection is essential for continued operation. Main fuel storage should be located away from loading docks, entrances, and parking. Access should be restricted and protected (e.g., locks on caps and seals). References: *GSA PBS-P100 and Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.12	**Where is the fuel supply obtained?** **How is it delivered?**	The supply of fuel is dependent on the reliability of the supplier. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.13	**Are there alternate sources of fuel?** **Can alternate fuels be used?**	Critical functions may be served by alternate methods if normal fuel supply is interrupted. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.14	**What is the normal source of electrical service for the site or building?**	Utilities are the general source unless co-generation or a private energy provider is available. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.15	**Is there a redundant electrical service source?** **Can the site or buildings be fed from more than one utility substation?**	The utility may have only one source of power from a single substation. There may be only single feeders from the main substation. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.16	**How many service entry points does the site or building have for electricity?**	Electrical supply at one location creates a vulnerable situation unless an alternate source is available. Ensure disconnecting requirements according to NFPA 70 (National Fire Protection Association, National Electric Code) are met for multiple service entrances. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.17	**Is the incoming electric service to the building secure?**	Typically, the service entrance is a locked room, inaccessible to the public. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

Section	Vulnerability Question	Guidance	Observations
5.18	**What provisions for emergency power exist? What systems receive emergency power and have capacity requirements been tested?** **Is the emergency power collocated with the commercial electric service?** **Is there an exterior connection for emergency power?**	Besides installed generators to supply emergency power, portable generators or rental generators available under emergency contract can be quickly connected to a building with an exterior quick disconnect already installed. Testing under actual loading and operational conditions ensures the critical systems requiring emergency power receive it with a high assurance of reliability. Reference: *GSA PBS-P100*	
5.19	**By what means do the main telephone and data communications interface the site or building?**	Typically, communication ducts or other conduits are available. Overhead service is more identifiable and vulnerable. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.20	**Are there multiple or redundant locations for the telephone and communications service?**	Secure locations of communications wiring entry to the site or building are required. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.21	**Does the fire alarm system require communication with external sources?** **By what method is the alarm signal sent to the responding agency: telephone, radio, etc.?** **Is there an intermediary alarm monitoring center?**	Typically, the local fire department responds to an alarm that sounds at the station or is transmitted over phone lines by an auto dialer. An intermediary control center for fire, security, and/or building system alarms may receive the initial notification at an on-site or off-site location. This center may then determine the necessary response and inform the responding agency. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
5.22	**Are utility lifelines aboveground, underground, or direct buried?**	Utility lifelines (water, power, communications, etc.) can be protected by concealing, burying, or encasing. References: *GSA PBS-P100 and FEMA 386-7*	

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6	**Mechanical Systems (HVAC and CBR)**		
6.1	**Where are the air intakes and exhaust louvers for the building? (low, high, or midpoint of the building structure)** **Are the intakes and exhausts accessible to the public?**	Air intakes should be located on the roof or as high as possible. Otherwise secure within CPTED-compliant fencing or enclosure. The fencing or enclosure should have a sloped roof to prevent the throwing of anything into the enclosure near the intakes. Reference: *GSA PBS-P100* states that air intakes should be on the fourth floor or higher and, on buildings with three floors or less, they should be on the roof or as high as practical. Locating intakes high on a wall is preferred over a roof location. Reference: *DoD UFC 4-010-01* states that, for all new inhabited buildings covered by this document, all air intakes should be located at least 3 meters (10 feet) above the ground. Reference: *CDC/NIOSH, Pub 2002-139* states: "An extension height of 12 feet (3.7 m) will place the intake out of reach of individuals without some assistance. Also, the entrance to the intake should be covered with a sloped metal mesh to reduce the threat of objects being tossed into the intake. A minimum slope of 45° is generally adequate. Extension height should be increased where existing platforms or building features (i.e., loading docks, retaining walls) might provide access to the outdoor air intakes". Reference: *LBNL PUB-51959:* Exhausts are also a concer n during an outdoor release, especially if exhaust fans are not in continuous operation, due to wind effects and chimney effects (air movement due to differential temperature).	
6.2	**Is roof access limited to authorized personnel by means of locking mechanisms?** **Is access to mechanical areas similarly controlled?**	Roofs are like entrances to the building and are like mechanical rooms when HVAC is installed. Adjacent structures or landscaping should not allow access to the roof. References: *GSA PBS-P100, CDC/NIOSH Pub 2002-139, and LBNL Pub 51959*	
6.3	**Are there multiple air intake locations?**	Single air intakes may feed several air handling units. Indicate if the air intakes are localized or separated. Installing low-leakage dampers is one way to provide the system separation when necessary. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
6.4	**What are the types of air filtration? Include the efficiency and number of filter modules for**	MERV – Minimum Efficiency Reporting Value HEPA – High Efficiency Particulate Air	

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	each of the main air handling systems? **Is there any collective protection for chemical, biological, and radiological contamination designed into the building?**	Activated charcoal for gases Ultraviolet C for biologicals Consider mix of approaches for optimum protection and cost-effectiveness. Reference: *CDC/NIOSH Pub 2002-139*	
6.5	**Is there space for larger filter assemblies on critical air handling systems?**	Air handling units serving critical functions during continued operation may be retrofitted to provide enhanced protection during emergencies. However, upgraded filtration may have negative effects upon the overall air handling system operation, such as increased pressure drop. Reference: *CDC/NIOSH Pub 2002-139*	
6.6	**Are there pprovisions for air monitors or sensors for chemical or biological agents?**	Duct mounted sensors are usuallly found in limited cases in laboratory areas. Sensors generally have a limited spectrum of high reliability and are costly. Many different technologies are undergoing research to provide capability. Reference: *CDC/NIOSH Pub 2002-139*	
6.7	**By what method are air intakes and exhausts closed when not operational?**	Motorized (low-leakage, fast-acting) dampers are the preferred method for closure with fail-safe to the closed position so as to support in-place sheltering. References: *CDC/NIOSH Pub 2002-139 and LBNL Pub 51959*	
6.8	**How are air handling systems zoned?** **What areas and functions do each of the primary air handling systems serve?**	Understanding the critical areas of the building that must continue functioning focuses security and hazard mitigation measures. Applying HVAC zones that isolate lobbies, mailrooms, loading docks, and other entry and storage areas from the rest of the building HVAC zones and maintaining negative pressure within these areas will contain CBR releases. Identify common return systems that service more than one zone, effectively making a large single zone. Conversely, emergency egress routes should receive positive pressurization to ensure contamination does not hinder egress. Consider filtering of the pressurization air. References: *CDC/NIOSH Pub 2002-139 and LBNL Pub 51959*	
6.9	**Are there large central air handling units or are there multiple units serving separate zones?**	Independent units can continue to operate if damage occurs to limited areas of the building. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

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6.10	**Are there any redundancies in the air handling system?** **Can critical areas be served from other units if a major system is disabled?**	Redundancy reduces the security measures required compared to a non-redundant situation. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
6.11	**Is the air supply to critical areas compartmentalized?** **Similarly, are the critical areas or the building as a whole, considered tight with little or no leakage?**	During chemical, biological, and radiological situations, the intent is to either keep the contamination localized in the critical area or prevent its entry into other critical, non-critical, or public areas. Systems can be cross-connected through building openings (doorways, ceilings, partial wall), ductwork leakage, or pressure differences in air handling system. In standard practice, there is almost always some air carried between ventilation zones by pressure imbalances, due to elevator piston action, chimney effect, and wind effects. Smoke testing of the air supply to critical areas may be necessary. Reference: *CDC/NIOSH Pub 2002-139 and LBNL Pub 51959*	
6.12	**Are supply, return, and exhaust air systems for critical areas secure?** **Are all supply and return ducts completely connected to their grilles and registers and secure?** **Is the return air not ducted?**	The air systems to critical areas should be inaccessible to the public, especially if the ductwork runs through the public areas of the building. It is also more secure to have a ducted air handling system versus sharing hallways and plenums above drop ceilings for return air. Non-ducted systems provide greater opportunity for introducing contaminants. Reference: *CDC/NIOSH Pub 2002-139 and LBNL Pub 51959*	
6.13	**What is the method of temperature and humidity control?** **Is it localized or centralized?**	Central systems can range from monitoring only to full control. Local control may be available to override central operation. Of greatest concern are systems needed before, during, and after an incident that may be unavailable due to temperature and humidity exceeding operational limits (e.g., main telephone switch room). Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
6.14	**Where are the building automation control centers and cabinets located?**	Access to any component of the building automation and control system could compromise the functioning of the system, increasing vulnerability to a hazard or precluding their proper operation during a hazard incident.	

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	Are they in secure areas? **How is the control wiring routed?**	The HVAC and exhaust system controls should be in a secure area that allows rapid shutdown or other activation based upon location and type of attack. References: *FEMA 386-7, DOC CIAO Vulnerability Assessment Framework 1.1 and LBNL Pub 51959*	
6.15	**Does the control of air handling systems support plans for sheltering in place or other protective approach?**	The micro-meteorological effects of buildings and terrain can alter travel and duration of chemical agents and hazardous material releases. Shielding in the form of sheltering in place can protect people and property from harmful effects. To support in-place sheltering, the air handling systems require the ability for authorized personnel to rapidly turn off all systems. However, if the system is properly filtered, then keeping the system operating will provide protection as long as the air handling system does not distribute an internal release to other portions of the building. Reference: *CDC/NIOSH Pub 2002-139*	
6.16	**Are there any smoke evacuation systems installed?** **Does it have purge capability?**	For an internal blast, a smoke removal system may be essential, particularly in large, open spaces. The equipment should be located away from high-risk areas, the system controls and wiring should be protected, and it should be connected to emergency power. This exhaust capability can be built into areas with significant risk on internal events, such as lobbies, loading docks, and mailrooms. Consider filtering of the exhaust to capture CBR contaminants. References: *GSA PBS-P100, CDC/NIOSH Pub 2002-139, and LBNL Pub 51959*	
6.17	**Where is roof-mounted equipment located on the roof? (near perimeter, at center of roof)**	Roof-mounted equipment should be kept away from the building perimeter. Reference: *U.S. Army TM 5-853*	
6.18	**Are fire dampers installed at all fire barriers?** **Are all dampers functional and seal well when closed?**	All dampers (fire, smoke, outdoor air, return air, bypass) must be functional for proper protection within the building during an incident. Reference: *CDC/NIOSH Pub 2002-139*	
6.19	**Do fire walls and fire doors maintain their integrity?**	The tightness of the building (both exterior, by weatherization to seal cracks around doors and windows, and internal, by zone ducting, fire walls, fire stops, and fire doors) provides energy conservation benefits and functional benefits during a CBR incident. Reference: *LBNL Pub 51959*	

Section	Vulnerability Question	Guidance	Observations
6.20	**Do elevators have recall capability and elevator emergency message capability?**	Although a life-safety code and fire response requirement, the control of elevators also has benefit during a CBR incident. The elevators generate a piston effect, causing pressure differentials in the elevator shaft and associated floors that can force contamination to flow up or down. Reference: *LBNL Pub 51959*	
6.21	**Is access to building information restricted?**	Information on building operations, schematics, procedures, plans, and specifications should be strictly controlled and available only to authorized personnel. References: *CDC/NIOSH Pub 2002-139 and LBNL Pub 51959*	
6.22	**Does the HVAC maintenance staff have the proper training, procedures, and preventive maintenance schedule to ensure CBR equipment is functional?**	Functional equipment must interface with operational procedures in an emergency plan to ensure the equipment is properly operated to provide the protection desired. The HVAC system can be operated in different ways, depending upon an external or internal release and where in the building an internal release occurs. Thus maintenance and security staff must have the training to properly operate the HVAC system under different circumstances, even if the procedure is to turn off all air movement equipment. Reference: *CDC/NIOSH Pub 2002-139 and LBNL Pub 51959*	
7	**Plumbing and Gas Systems**		
7.1	**What is the method of water distribution?**	Central shaft locations for piping are more vulnerable than multiple riser locations. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
7.2	**What is the method of gas distribution? (heating, cooking, medical, process)**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
7.3	**Is there redundancy to the main piping distribution?**	Looping of piping and use of section valves provide redundancies in the event sections of the system are damaged. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

Section	Vulnerability Question	Guidance	Observations
7.4	**What is the method of heating domestic water?** **What fuel(s) is used?**	Single source of hot water with one fuel source is more vulnerable than multiple sources and multiple fuel types. Domestic hot water availability is an operational concern for many building occupancies. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
7.5	**Where are gas storage tanks located? (heating, cooking, medical, process)** **How are they piped to the distribution system? (above or below ground)**	The concern is that the tanks and piping could be vulnerable to a moving vehicle or a bomb blast either directly or by collateral damage due to proximity to a higher-risk area. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
7.6	**Are there reserve supplies of critical gases?**	Localized gas cylinders could be available in the event of damage to the central tank system. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
8	**Electrical Systems**		
8.1	**Are there any transformers or switchgears located outside the building or accessible from the building exterior?** **Are they vulnerable to public access?** **Are they secured?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
8.2	**What is the extent of the external building lighting in utility and service areas and at normal entryways used by the building occupants?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
8.3	**How are the electrical rooms secured and where are they located relative to other higher-risk areas, starting with the main electrical distribution room at the service entrance?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

Section	Vulnerability Question	Guidance	Observations
8.4	**Are critical electrical systems collocated with other building systems?** **Are critical electrical systems located in areas outside of secured electrical areas?** **Is security system wiring located separately from electrical and other service systems?**	Collocation concerns include rooms, ceilings, raceways, conduits, panels, and risers. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
8.5	**How are electrical distribution panels serving branch circuits secured or are they in secure locations?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
8.6	**Does emergency backup power exist for all areas within the building or for critical areas only?** **How is the emergency power distributed?** **Is the emergency power system independent from the normal electrical service, particularly in critical areas?**	There should be no single critical node that allows both the normal electrical service and the emergency backup power to be affected by a single incident. Automatic transfer switches and interconnecting switchgear are the initial concerns. Emergency and normal electrical equipment should be installed separately, at different locations, and as far apart as possible. Reference: *GSA PBS-P100*	
8.7	**How is the primary electrical system wiring distributed?** **Is it collocated with other major utilities?** **Is there redundancy of distribution to critical areas?**	Central utility shafts may be subject to damage, especially if there is only one for the building. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

Section	Vulnerability Question	Guidance	Observations
9	**Fire Alarm Systems**		
9.1	**Is the building fire alarm system centralized or localized?** **How are alarms made known, both locally and centrally?** **Are critical documents and control systems located in a secure yet accessible location?**	Fire alarm systems must first warn building occupants to evacuate for life safety. Then they must inform the responding agency to dispatch fire equipment and personnel. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
9.2	**Where are the fire alarm panels located?** **Do they allow access to unauthorized personnel?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
9.3	**Is the fire alarm system standalone or integrated with other functions such as security and environmental or building management systems?** **What is the interface?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
9.4	**Do key fire alarm system components have fire- and blast-resistant separation?**	This is especially necessary for the fire command center or fire alarm control center. The concern is to similarly protect critical components as described in Items 2.19, 5.7, and 10.3.	
9.5	**Is there redundant off-premises fire alarm reporting?**	Fire alarms can ring at a fire station, at an intermediary alarm monitoring center, or autodial someone else. See Items 5.21 and 10.5.	
10	**Communications and IT Systems**		
10.1	**Where is the main telephone distribution room and where is it in relation to higher-risk areas?** **Is the main telephone distribution room secure?**	One can expect to find voice, data, signal, and alarm systems to be routed through the main telephone distribution room. Reference: *FEMA 386-7*	

Section	Vulnerability Question	Guidance	Observations
10.2	**Does the telephone system have an uninterruptible power supply (UPS)?** **What is its type, power rating, and operational duration under load, and location? (battery, on-line, filtered)**	Many telephone systems are now computerized and need a UPS to ensure reliability during power fluctuations. The UPS is also needed to await any emergency power coming on line or allow orderly shutdown. Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
10.3	**Where are communication systems wiring closets located? (voice, data, signal, alarm)** **Are they collocated with other utilities?** **Are they in secure areas?**	Concern is to have separation distance from other utilities and higher-risk areas to avoid collateral damage. Security approaches on the closets include door alarms, closed circuit television, swipe cards, or other logging notifications to ensure only authorized personnel have access to these closets. Reference: *FEMA 386-7*	
10.4	**How is the communications system wiring distributed? (secure chases and risers, accessible public areas)**	The intent is to prevent tampering with the systems. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
10.5	**Are there redundant communications systems available?**	Critical areas should be supplied with multiple or redundant means of communications. Power outage phones can provide redundancy as they connect directly to the local commercial telephone switch off site and not through the building telephone switch in the main telephone distribution room. A base radio communication system with antenna can be installed in stairwells, and portable sets distributed to floors. References: *GSA PBS-P100 and FEMA 386-7*	
10.6	**Where are the main distribution facility, data centers, routers, firewalls, and servers located and are they secure?** **Where are the secondary and/or intermediate distribution facilities and are they secure?**	Concern is collateral damage from manmade hazards and redundancy of critical functions. Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
10.7	**What type and where are the Wide Area Network (WAN) connections?**	Critical facilities should have two Minimum-Points-of-Presence(MPOPs) where the telephone company's outside cable terminates inside the building. It is functionally a service entrance connection that demarcates where the telephone company's property stops and the building owner's property begins. The MPOPs should not be	

Section	Vulnerability Question	Guidance	Observations
		collocated and they should connect to different telephone company central offices so that the loss of one cable or central office does not reduce capability. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
10.8	**What are the type, power rating, and location of the uninterruptible power supply?** (battery, on-line, filtered) **Are the UPS also connected to emergency power?**	Consider that UPS should be found at all computerized points from the main distribution facility to individual data closets and at critical personal computers/terminals. Critical LAN sections should also be on backup power. Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
10.9	**What type of Local Area Network (LAN) cabling and physical topology is used?** (Category (Cat) 5, Gigabit Ethernet, Ethernet, Token Ring)	The physical topology of a network is the way in which the cables and computers are connected to each other. The main types of physical topologies are: Bus (single radial where any damage on the bus affects the whole system, but especially all portions downstream) Star (several computes are connected to a hub and many hubs can be in the network – the hubs can be critical nodes, but the other hubs continue to function if one fails) Ring (a bus with a continuous connection - least used, but can tolerate some damage because if the ring fails at a single point it can be rerouted much like a looped electric or water system) The configuration and the availability of surplus cable or spare capacity on individual cables can reduce vulnerability to hazard incidents. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
10.10	**For installed radio/wireless systems, what are their types and where are they located?** (radio frequency (RF), high frequency (HF), very high frequency (VHF), medium wave (MW))	Depending upon the function of the wireless system, it could be susceptible to accidental or intended jamming or collateral damage. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
10.11	**Do the Information Technology (IT - computer) systems meet requirements of confidentiality, integrity, and availability?**	Ensure access to terminals and equipment for authorized personnel only and ensure system up-time to meet operational needs. Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	

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10.12	**Where is the disaster recovery/ mirroring site?**	A site with suitable equipment that allows continuation of operations or that mirrors (operates in parallel to) the existing operation is beneficial if equipment is lost during a natural or manmade disaster. The need is based upon the criticality of the operation and how quickly replacement equipment can be put in place and operated. Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
10.13	**Where is the backup tape/file storage site and what is the type of safe environment?** (safe, vault, underground) **Is there redundant refrigeration in the site?**	If equipment is lost, data are most likely lost, too. Backups are needed to continue operations at the disaster recovery site or when equipment can be delivered and installed. Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
10.14	**Are there any satellite communications (SATCOM) links?** (location, power, UPS, emergency power, spare capacity/capability)	SATCOM links can serve as redundant communications for voice and data if configured to support required capability after a hazard incident. Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
10.15	**Is there a mass notification system that reaches all building occupants?** (public address, pager, cell phone, computer override, etc.) **Will one or more of these systems be operational under hazard conditions?** (UPS, emergency power)	Depending upon building size, a mass notification system will provide warning and alert information, along with actions to take before and after an incident if there is redundancy and power. Reference: *DoD UFC 4-010-01*	
10.16	**Do control centers and their designated alternate locations have equivalent or reduced capability for voice, data, mass notification, etc.? (emergency operations, security, fire alarms, building automation)** **Do the alternate locations also have access to backup systems, including emergency power?**	Reference: *GSA PBS-P100*	

Section	Vulnerability Question	Guidance	Observations
11	**Equipment Operations and Maintenance**		
11.1	**Are there composite drawings indicating location and capacities of major systems and are they current?** (electrical, mechanical, and fire protection; and date of last update) **Do updated operations and maintenance (O&M) manuals exist?**	Within critical infrastructure protection at the building level, the current configuration and capacity of all critical systems must be understood to ensure they meet emergency needs. Manuals must also be current to ensure operations and maintenance keeps these systems properly functioning. The system must function during an emergency unless directly affected by the hazard incident. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
11.2	**Have critical air systems been rebalanced?** **If so, when and how often?**	Although the system may function, it must be tested periodically to ensure it is performing as designed. Balancing is also critical after initial construction to set equipment to proper performance per the design. Rebalancing may only occur during renovation. Reference: *CDC/NIOSH Pub 2002-139*	
11.3	**Is air pressurization monitored regularly?**	Some areas require positive or negative pressure to function properly. Pressurization is critical in a hazardous environment or emergency situation. Measuring pressure drop across filters is an indication when filters should be changed, but also may indicate that low pressures are developing downstream and could result in loss of expected protection. Reference: *CDC/NIOSH Pub 2002-139*	
11.4	**Does the building have a policy or procedure for periodic recommissioning of major Mechanical/Electrical/Plumbing (M/E/P) systems?**	Recommissioning involves testing and balancing of systems to ascertain their capability to perform as described. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
11.5	**Is there an adequate O&M program, including training of facilities management staff?**	If O&M of critical systems is done with in-house personnel, management must know what needs to be done and the workforce must have the necessary training to ensure systems reliability. Reference: *CDC/NIOSH Pub 2002-139*	
11.6	**What maintenance and service agreements exist for M/E/P systems?**	When an in-house facility maintenance work force does not exist or does not have the capability to perform the work, maintenance and service contracts are the alternative to ensure critical systems will work under all	

Section	Vulnerability Question	Guidance	Observations
		conditions. The facility management staff requires the same knowledge to oversee these contracts as if the work was being done by in-house personnel. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
11.7	**Are backup power systems periodically tested under load?**	Loading should be at or above maximum connected load to ensure available capacity and automatic sensors should be tested at least once per year. Periodically (once a year as a minimum) check the duration of capacity of backup systems by running them for the expected emergency duration or estimating operational duration through fuel consumption, water consumption, or voltage loss. Reference: *FEMA 386-7*	
11.8	**Is stairway and exit sign lighting operational?**	The maintenance program for stairway and exit sign lighting (all egress lighting) should ensure functioning under normal and emergency power conditions. Expect building codes to be updated as emergency egress lighting is moved from upper walls and over doorways to floor level as heat and smoke drive occupants to crawl along the floor to get out of the building. Signs and lights mounted high have limited or no benefit when obscured. Reference: *FEMA 386-7*	
12	**Security Systems**		
	Perimeter Systems		
12.1	**Are black/white or color CCTV (closed circuit television) cameras used?** **Are they monitored and recorded 24 hours/7 days a week? By whom?** **Are they analog or digital by design?** **What are the number of fixed, wireless, and pan-tilt-zoom cameras used?**	Security technology is frequently considered to complement or supplement security personnel forces and to provide a wider area of coverage. Typically, these physical security elements provide the first line of defense in deterring, detecting, and responding to threats and reducing vulnerabilities. They must be viewed as an integral component of the overall security program. Their design, engineering, installation, operation, and management must be able to meet daily security challenges from a cost-effective and efficiency perspective. During and after an incident, the system, or its backups, should be functional per the planned design. Consider color CCTV cameras to view and record activity at the perimeter of the building, particularly at primary entrances and exits. A mix of monochrome cameras	

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	Who are the manufacturers of the CCTV cameras? **What is the age of the CCTV cameras in use?**	should be considered for areas that lack adequate illumination for color cameras. Reference: *GSA PBS P-100*	
12.2	**Are the cameras programmed to respond automatically to perimeter building alarm events?** **Do they have built-in video motion capabilities?**	The efficiency of monitoring multiple screens decreases as the number of screens increases. Tying the alarm system or motion sensors to a CCTV camera and a monitoring screen improves the man-machine interface by drawing attention to a specific screen and its associated camera. Adjustment may be required after installation due to initial false alarms, usually caused by wind or small animals. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.3	**What type of camera housings are used and are they environmental in design to protect against exposure to heat and cold weather elements?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.4	**Are panic/duress alarm buttons or sensors used, where are they located, and are they hardwired or portable?**	Call buttons should be provided at key public contact areas and as needed in offices of managers and directors, in garages and parking lots, and other high-risk locations by assessment. Reference: *GSA PBS P-100*	
12.5	**Are intercom call boxes used in parking areas or along the building perimeter?**	See Item 12.4.	
12.6	**What is the transmission media used to transmit camera video signals: fiber, wire line, telephone wire, coaxial, wireless?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.7	**Who monitors the CCTV system?**	Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	

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12.8	**What is the quality of video images both during the day and hours of darkness?** **Are infrared camera illuminators used?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.9	**Are the perimeter cameras supported by an uninterruptible power supply, battery, or building emergency power?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.10	**What type of exterior Intrusion Detection System (IDS) sensors are used?** (electromagnetic; fiber optic; active infrared; bistatic microwave; seismic; photoelectric; ground; fence; glass break (vibration/shock); single, double, and roll-up door magnetic contacts or switches)	Consider balanced magnetic contact switch sets for all exterior doors, including overhead/roll-up doors, and review roof intrusion detection. Consider glass break sensors for windows up to scalable heights. Reference: *GSA PBS-P100*	
12.11	**Is a global positioning system (GPS) used to monitor vehicles and asset movements?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
	Interior Security		
12.12	**Are black/white or color CCTV cameras used?** **Are they monitored and recorded 24 hours/7 days a week? By whom?** **Are they analog or digital by design?** **What are the number of fixed, wireless, and pan-tilt-zoom cameras used?** **Who are the manufacturers of the CCTV cameras?** **What is the age of the CCTV cameras in use?**	See Item 12.1. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

Section	Vulnerability Question	Guidance	Observations
12.13	**Are the cameras programmed to respond automatically to interior building alarm events?** **Do they have built-in video motion capabilities?**	The efficiency of monitoring multiple screens decreases as the number of screens increases. Tying the alarm system or motion sensors to a CCTV camera and a monitoring screen improves the man-machine interface by drawing attention to a specific screen and its associated camera. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.14	**What type of camera housings are used and are they designed to protect against exposure or tampering?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.15	**Do the camera lenses used have the proper specifications, especially distance viewing and clarity?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.16	**What is the transmission media used to transmit camera video signals: fiber, wire line, telephone wire, coaxial, wireless?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.17	**Are the interior camera video images of good visual and recording quality?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.18	**Are the interior cameras supported by an uninterruptible power supply source, battery, or building emergency power?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.19	**What are the first costs and maintenance costs associated with the interior cameras?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.20	**What type of security access control system is used?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

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	Are the devices used for physical security also used (integrated) with security computer networks (e.g., in place of or in combination with user ID and system passwords)?		
12.21	**What type of access control transmission media is used to transmit access control system signals (same as defined for CCTV cameras)?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.22	**What is the backup power supply source for the access control systems?** (battery, uninterruptible power supply)	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.23	**What access control system equipment is used?** **How old are the systems and what are the related first and maintenance service costs?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.24	**Are panic/duress alarm sensors used?** **Where are they located?** **Are they hardwired or portable?**	Call buttons should be provided at key public contact areas and as needed in offices of managers and directors, in garages and parking lots, and other high-risk locations by assessment. Reference: *GSA PBS P-100*	
12.25	**Are intercom call-boxes or a building intercom system used throughout the building?**	See Item 12.24.	
12.26	**Are magnetometers (metal detectors) and x-ray equipment used?** **At what locations within the building?**	Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	

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12.27	**What type of interior IDS sensors are used: electromagnetic; fiber optic; active infrared-motion detector; photoelectric; glass break (vibration/shock); single, double, and roll-up door magnetic contacts or switches?**	Consider magnetic reed switches for interior doors and openings. Reference: *GSA PBS-P100*	
12.28	**Are mechanical, electrical, gas, power supply, radiological material storage, voice/data telecommunication system nodes, security system panels, elevator and critical system panels, and other sensitive rooms continuously locked, under electronic security, CCTV camera, and intrusion alarm systems surveillance?**	Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
12.29	**What types of locking hardware are used throughout the building?** **Are manual and electromagnetic cipher, keypad, pushbutton, panic bar, door strikes, and related hardware and software used?**	As a minimum, electric utility closets, mechanical rooms, and telephone closets should be secured. The mailroom should also be secured, allowing only authorized personnel into the area where mail is screened and sorted. Separate the public access area from the screening area for the postulated mailroom threats. All security locking arrangements on doors used for egress must comply with *NFPA 101, Life Safety Code.* Reference: *GSA PBS-P100*	
12.30	**Are any potentially hazardous chemicals, combustible, or toxic materials stored on site in non-secure and non-monitored areas?**	The storage, use, and handling locations should also be kept away from other activities. The concern is that an intruder need not bring the material into the building if it is already there and accessible. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.31	**What security controls are in place to handle the processing of mail and protect against potential biological, explosive, or other threatening exposures?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

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12.32	**Is there a designated security control room and console in place to monitor security, fire alarm, and other building systems?** **Is there a backup control center designated and equipped?** **Is there off-site 24-hour monitoring of intrusion detection systems?**	Monitoring can be done at an off-site facility, at an on-site monitoring center during normal duty hours, or at a 24-hour on-site monitoring center. Reference: *GSA PBS-P100*	
12.33	**Is the security console and control room adequate in size and does it provide room for expansion?** **Does it have adequate environment controls (e.g., a/c, lighting, heating, air circulation, backup power)?** **Is it ergonomically designed?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.34	**Is the location of the security room in a secure area with limited, controlled, and restricted access controls in place?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.35	**What are the means by which facility and security personnel can communicate with one another (e.g., portable radio, pager, cell phone, personal data assistants (PDAs))?** **What problems have been experienced with these and other electronic security systems?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.36	**Is there a computerized security incident reporting system used to prepare reports and track security incident trends and patterns?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.37	**Does the current security force have access to a computerized guard tour system?**	This system allows for the systematic performance of guard patrols with validation indicators built in. The system notes stations/locations checked or missed, dates	

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		and times of such patrols, and who conducted them on what shifts. Management reports can be produced for recordkeeping and manpower analysis purposes. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.38	**Are vaults or safes in the building?** **Where are they located?**	Basic structural design requires an understanding of where heavy concentrations of floor loading may occur so as to strengthen the floor and structural framing to handle this downward load. Security design also needs this information to analyze how this concentrated load affects upward and downward loadings under blast conditions and its impact upon progressive collapse. Location is important because safes can be moved by blast so that they should be located away from people and away from exterior windows. Vaults, on the other hand, require construction above the building requirements with thick masonry walls and steel reinforcement. A vault can provide protection in many instances due to its robust construction. Safes and vaults may also require security sensors and equipment, depending upon the level of protection and defensive layers needed. Reference: *U.S. Army TM 5-85*	
	Security System Documents		
12.39	**Have security system as-built drawings been generated and are they ready for review?**	Drawings are critical to the consideration and operation of security technologies, including its overall design and engineering processes. These historical reference documents outline system specifications and layout security devices used, as well as their application, location, and connectivity. They are a critical resource tool for troubleshooting system problems, and replacing and adding other security system hardware and software products. Such documents are an integral component to new and retrofit construction projects. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.40	**Have security system design and drawing standards been developed?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.41	**Are security equipment selection criteria defined?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

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12.42	What contingency plans have been developed or are in place to deal with security control center redundancy and backup operations?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.43	Have security system construction specification documents been prepared and standardized?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.44	Do all security system documents include current as-built drawings?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.45	Have qualifications been determined for security consultants, system designers/ engineers, installation vendors, and contractors?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.46	Are security systems decentralized, centralized, or integrated? Do they operate over an existing IT network or are they a standalone method of operation?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.47	What security systems manuals are available?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
12.48	What maintenance or service agreements exist for security systems?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

Section	Vulnerability Question	Guidance	Observations
13	**Security Master Plan**		
13.1	**Does a written security plan exist for this site or building?** **When was the initial security plan written and last revised?** **Who is responsible for preparing and reviewing the security plan?**	The development and implementation of a security master plan provides a roadmap that outlines the strategic direction and vision, operational, managerial, and technological mission, goals, and objectives of the organization's security program. Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
13.2	**Has the security plan been communicated and disseminated to key management personnel and departments?**	The security plan should be part of the building design so that the construction or renovation of the structure integrates with the security procedures to be used during daily operations. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.3	**Has the security plan been benchmarked or compared against related organizations and operational entities?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.4	**Has the security plan ever been tested and evaluated from a benefit/cost and operational efficiency and effectiveness perspective?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.5	**Does the security plan define mission, vision, and short- and long- term security program goals and objectives?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.6	**Are threats/hazards, vulnerabilities, and risks adequately defined and security countermeasures addressed and prioritized relevant to their criticality and probability of occurrence?**	Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	
13.7	**Has a security implementation schedule been established to address recommended security solutions?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	

Section	Vulnerability Question	Guidance	Observations
13.8	**Have security operating and capital budgets been addressed, approved, and established to support the plan?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.9	**What regulatory or industry guidelines/standards were followed in the preparation of the security plan?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.10	**Does the security plan address existing security conditions from an administrative, operational, managerial, and technical security systems perspective?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.11	**Does the security plan address the protection of people, property, assets, and information?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.12	**Does the security plan address the following major components: access control, surveillance, response, building hardening, and protection against CBR and cyber-network attacks?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.13	**Has the level of risk been identified and communicated in the security plan through the performance of a physical security assessment?**	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	
13.14	**When was the last security assessment performed?** **Who performed the security risk assessment?**	Reference: *DOC CIAO Vulnerability Assessment Framework 1.1*	

Section	Vulnerability Question	Guidance	Observations
13.15	**Are the following areas of security analysis addressed in the security master plan?** **Asset Analysis:** Does the security plan identify and prioritize the assets to be protected in accordance to their location, control, current value, and replacement value? **Threat Analysis:** Does the security plan address potential threats; causes of potential harm in the form of death, injury, destruction, disclosure, interruption of operations, or denial of services? (possible criminal acts [documented and review of police/security incident reports] associated with forced entry, bombs, ballistic assault, biochemical and related terrorist tactics, attacks against utility systems infrastructure and buildings) **Vulnerability Analysis:** Does the security plan address other areas associated with the site or building and its operations that can be taken advantage of to carry out a threat? (architectural design and construction of new and existing buildings, technological support systems [e.g., heating, air conditioning, power, lighting and security systems, etc.] and operational procedures, policies, and controls) **Risk Analysis**: Does the security plan address the findings from the asset, threat/hazard, and vulnerability analyses in order to develop, recommend, and consider implementation of appropriate security countermeasures?	This process is the input to the building design and what mitigation measures will be included in the facility project to reduce risk and increase safety of the building and people. Reference: *USA TM 5-853, Security Engineering*	

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