ANTITERRORISM
DESIGN GUIDELINES

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2005
NOTICE

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INTRODUCTION

1.1 DEFINITION OF TERRORISM

A civilization’s progress is best measured by its appreciation of the individual and the rights and freedom of that individual. Dogma...political, religious, social...has no role in a truly civilized society. However, terrorism is based on total disregard for the individual, either as a "player" or as a victim.

The dictionary definition of terrorism is “the systematic use of terror or unpredictable violence against governments, publics, or individuals to attain a political objective. Terrorism has been used by political organizations with both rightist and leftist objectives, by nationalistic and ethnic groups, by revolutionaries, and by the armies and secret police of governments themselves.”

The word was coined during France’s "Reign of Terror" (1793-94). Originally, the leaders of this systematic attempt to weed out "traitors" among the revolutionary ranks praised terror as the best way to defend liberty, but as the French revolution soured, the word soon took on grim connotation of state-sponsored violence.

Terrorism is defined in the U.S. by the Code of Federal Regulations (CFR) as: "...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."

The State Department defines terrorism as "premeditated, politically motivated violence perpetrated against noncombatant targets by subnational groups or clandestine agents, usually intended to influence an audience."

In another useful attempt to produce a definition, Paul Pillar, a former deputy chief of the CIA’s Counterterrorist Center, argues that there are four key elements of terrorism:

1. It is premeditated—planned in advance, rather than an impulsive act of rage.

2. It is political—not criminal, like the violence that groups such as the Mafia use to get money, but designed to change an existing political order.

3. It is aimed at civilians—not at military targets or combat-ready troops.
4. It is carried out by subnational groups—not by the army of a country.

The FBI further describes terrorism as either domestic or international, depending on the origin, base, and objectives of the terrorists:

"Domestic terrorism is the unlawful use, or threatened use, of force or violence by a group or individual based and operating entirely within the United States or its territories 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.

"International terrorism involves violent 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 the perpetrators operate or seek asylum."

However, the grouping of terrorists into domestic or international categories may be superficial. A recent report from the Southern Poverty Law Center shows that religious extremism and hard-line theocratic thinking — the idea that government and the legal system must be structured along religious lines — is the major root of both domestic and international hate groups. Both groups share tactics and, in many cases, targets.

Two terms currently widely (and often erroneously) used when discussing terrorism require clarification:

**Antiterrorism** represents the defensive or passive measures taken to avoid a terrorist attack and the steps taken to mitigate the impact of an attack.

**Counter terrorism** includes the offensive or active measures taken to eliminate potential terrorism and its propagators.

This text is concerned only with antiterrorism measures applied to protect buildings, and more importantly, their occupants.

### 1.2 DOMESTIC TERRORISM

As San Francisco police were arresting more than 150 people protesting the Biotechnology Industry Organization in June 2004, an FBI agent stood inside the conference center, speaking to a group of scientists, pharmaceutical representatives, and biotechnology executives. His message: the FBI considers "ecoterrorism" and "animal terrorism" the country's leading domestic terror threats.

For the better part of a decade, the Earth Liberation Front (ELF) and Animal Liberation Front (ALF) were seen not as antisocial thugs, but as idealistic young kids. After all, the public generally supported their goals: a clean environment and compassion toward animals. Then
came September 11, 2001. That was the day the ELF and ALF took joint credit for firebombing a McDonald's in Tucson, Arizona on September 8, 2001, as shown in the following photo:

![Image of a McDonald's on fire]

**Animal Liberation Front:** According to its posted "credo," the ALF carries out direct action against animal abuse in the form of rescuing animals and causing financial loss to animal exploiters, *usually through the damage and destruction of property.* The ALF’s short-term aim is to save as many animals as possible and directly disrupt the practice of animal abuse. Their long-term aim is to end all animal suffering by forcing animal abuse companies out of business. So far, it has been a "nonviolent" campaign, activists taking all precautions not to harm any animal (human or otherwise).

Because ALF actions are against the law, its members work anonymously, either in small groups or individually, and do not have any centralized organization or coordination. The ALF consists of small autonomous groups of people all over the world that carry out direct action according to the ALF guidelines.

The stated ALF guidelines are:

1. To liberate animals from places of abuse, i.e. laboratories, factory farms, fur farms, etc., and place them in good homes where they may live out their natural lives, free from suffering;

2. To inflict economic damage to those who profit from the misery and exploitation of animals;

3. To reveal the horror and atrocities committed against animals behind locked doors by performing non-violent direct actions and liberations; and

4. To take all necessary precautions against harming any animal, human and non-human.
This last goal, however, is undergoing change; ALF spokesmen have recently begun to move away from pledging to avoid harming humans. Seeing the success of international terrorists, they appear to be willing to escalate their actions to include human attacks.

People for the Ethical Treatment of Animals (PETA), one of the more rabid, radical, and influential environmental groups on the scene today, support the ALF. As an advocate of animal rights philosophy, PETA has agitated to:

1. Eliminate the meat industry ("we're absolutely opposed to breeding animals for humans");
2. Abolish the use of furs from fur farms or wild animals;
3. Stop all hunting ("there's something fundamentally wrong with a person who feels that it's acceptable to go out into the woods, and for fun, slaughter") and fishing ("fish suffocate");
4. Eliminate the use of animals in entertainment, medical research and military research;
5. Prevent the use of all animal products such as wool ("we don't need wool") and silk ("silkworms can feel pain"); and
6. Stop the ownership of animals as pets.

PETA promotes veganism, an animal rights philosophy far more radical than vegetarianism. Veganism, as well as it can be represented accurately, is the ideal that no animal food be consumed in any way, not even milk or eggs, and that no harm of any sort be done by humans to any animal because there is no moral difference between humans and animals.

*The core of the animal rights philosophy is the dismissal of differences between people and animals—language, reason, morality, freewill—as ethically irrelevant.* Animal rights assign equal moral status to all living things based on the ability to feel pain. In this ethic, all human use of animals for food, clothing, sport, companionship, medical research, is "speciesism," the moral equivalent of racism.

**Earth Liberation Front:** The ELF's web site describes it as an "international underground movement consisting of autonomous groups of people who carry out direct action according to the ELF guidelines." In fact, ELF, like some other terrorist groups, adheres to the principal of *leaderless resistance.*

Developed by Ku Klux Klan (KKK) and Aryan Nations activist Louis Beam, leaderless resistance is a technique by which terrorist groups carry out violent acts while reducing the risk of infiltration by law enforcement elements. The basic principle of leaderless resistance is that there is no centralized authority or chain-of-command. The various cells are linked by shared ideology but otherwise are autonomous, for the most part unconnected and unknown to each other.

The ELF web site advises prospective members not to try to join existing cells, as such efforts would be fruitless and could threaten the organization, but, rather to form their
own cell and proclaim membership in the ELF by attacking the property of those who seek to despoil the environment. Moreover, the web site says this about the organization’s operating philosophy:

“By operating in cells (small groups that consist of one to several people), the security of group members is maintained. Each cell is anonymous not only to the public but also to one another. This decentralized structure helps keep activists out of jail and free to continue conducting actions.”

This lack of formal organization makes it extremely difficult for law enforcement to penetrate the ELF as, in reality, it is more of an amorphous movement than an organization in any conventional sense of the word. According to Bob Holland, a Eugene, Oregon police detective who has been investigating ecoterrorism for several years, members “know each other and don’t tolerate strangers.” The lack of organization also seems to fit the anti-authoritarian orientation of many ELF activists.

Two fundamental concepts motivate environmental terrorists: biocentrism and deep ecology. **Biocentrism** is the belief that all organisms on earth are equal and deserving of moral rights and considerations. They see biodiversity and wilderness as absolute goods. Believers in **deep ecology** favor a rollback of industrialization/civilization and return to a way of life seen as more consistent with preservation of the environment. In this regard, their views resemble those of the “Unibomber” Theodore Kaczynski (Kaczynski’s lengthy manifesto began with the assertion that the industrial revolution has been a disaster for the human race).

Deep ecologists favor restoration of the world to its imagined pristine state, of an environment they believe has been despoiled by the selfish actions of the human race. In practice, this would mean return to pre-industrial, subsistence agricultural communities. “Knock down all the concrete,” is the way one ELF sympathizer puts it. Indeed, February 2002 testimony by former ELF spokesman Craig Rosebraugh makes clear that ELF sees itself linked to the anti-globalization movement that contains anarchist and anti-capitalist elements.

The ELF web site lists the following goals and guidelines:

1. To inflict economic damage on those profiting from the destruction and exploitation of the natural environment.

2. To reveal and educate the public on the atrocities committed against the earth and all species that populate it.

3. To take all necessary precautions against harming any animal, human and non-human.

Underlying the first guideline is a fundamental hostility to the U.S. capitalist economic system and a belief that the system is a fundamental threat to global environment. ELF leaders, at the very least, appear to believe that the capitalist system must be destroyed.

*The FBI now ranks both ALF and ELF as the No. 1 domestic terrorism threats, surpassing the militia extremists who dominated the terrorism scene during much of the 1990s. The FBI estimates that the ALF/ELF have committed more than 600 criminal acts in the United States*
since 1996, resulting in damages in excess of $43 million,” said James Jarboe, FBI domestic-terrorism section chief, at a February 2004 hearing before the House Resources subcommittee on Forests and Forest Health.

More widely recognized domestic terrorists include the right-wing religious and white supremacist organizations that spawned the bombers of the Federal office building in Oklahoma City in 1995 (shown in the following photo), the bombing of abortion clinics around the country, and the 1996 Olympics bombing in Atlanta, GA.

In 2004, The Southern Poverty Law Center identified over 700 “hate groups,” organizations and their individual chapters, in the United States. The Center classifies these hate groups as follows:

**Black Separatist:** Black separatists typically oppose integration and racial intermarriage, and they want separate institutions -- or even a separate nation -- for blacks. Most forms of black separatism are strongly anti-white and anti-Semitic, and a number of religious versions assert that blacks -- not Jews -- are the Biblical “chosen people” of God.

**Christian Identity:** The Christian Identity religion asserts that whites, not Jews, are the true Israelites favored by God in the Bible. In most of its forms, Identity theology depicts Jews as biologically descended from Satan, while non-whites are seen as soulless “mud people” created with the other Biblical “beasts of the field.” Christian Identity has its roots in a 19th-century English fad called British Israelism, which asserted that European whites were descended from the ten "lost tribes" of Israel and were thus related to Jews, who were descended from the other two Hebrew tribes mentioned in the Bible. But British Israelism, which was initially friendly to Jews, was adopted and transformed in the 20th century into a rabidly anti-Semitic creed by a number of racist preachers in the United States.

For decades, Christian Identity has been one of the most important ideologies for the white supremacist movement. In its hardest line form, it asserts that Christ will not return to earth until the globe is swept clean of Jews and other “Satanic” influences. In recent
years, deep doctrinal disputes, the lack of a central church structure, and a shift among
white supremacists towards agnosticism and racist variations of neo-Paganism have
weakened the Identity movement and reduced the number of its adherents.

Ku Klux Klan: The Ku Klux Klan, with its mystique and its long history of violence, is the
most infamous -- and oldest -- of American hate groups. Although blacks have typically
been the Klan's primary target, it also has attacked Jews, immigrants, homosexuals and,
until recently, Catholics. Over the years since it was formed in December 1865, the Klan
has typically seen itself as a Christian organization, although in modern times Klan
groups are motivated by a variety of theological and political ideologies.

Started during Reconstruction at the end of the Civil War, the Klan quickly mobilized as a
vigilante group to intimidate Southern blacks -- and any whites that would help them --
and to prevent them from enjoying basic civil rights. Outlandish titles (like Imperial
Wizard and Exalted Cyclops), hooded costumes, violent "night rides," and the notion that
the group comprised an "invisible empire" conferred a mystique that only added to the
Klan's popularity. Lynchings, tar-and-featherings, rape and other violent attacks on
those challenging white supremacy became hallmarks of the Klan.

After a short but violent period, the "first era" Klan disbanded after Jim Crow laws
secured the domination of Southern whites. But the Klan enjoyed a huge revival in the
1920s when it opposed (mainly Catholic and Jewish) immigration. By 1925, when its
followers staged a Washington, DC march, the Klan had as many as 5 million members
and, in some states, considerable political power. But a series of sex scandals, internal
battles over power, and newspaper exposés quickly reduced its influence.

The Klan arose a third time during the 1960s to oppose the civil rights movement and to
preserve segregation in the face of unfavorable court rulings. The Klan's bombings,
murders, and other attacks took a great many lives including, among others, four young
girls killed while preparing for services at the 16th Street Baptist Church in Birmingham,
Alabama.

Since the 1970s the Klan has been greatly weakened by internal conflicts, court cases, a
seemingly endless series of splits and government infiltration. While some factions have
preserved an openly racist and militant approach, others have tried to enter the
mainstream, cloaking their racism as mere "civil rights for whites." Today, the Center
estimates that there are a total of 5,500 to 6,000 Klan members, split among scores of
different, often warring, organizations that use the Klan name.

Neo-Confederate: Many groups celebrate traditional Southern culture and the Civil
War's dramatic conflict between the Union and the Confederacy. But some groups go
further and embrace racist attitudes towards blacks and, in some cases, white
separatism. Such groups are listed in this category.

The League of the South, founded in 1994 and counting some 9,000 members by 2001,
is at the center of the racist neo-Confederate movement. Calling once again for
Southern secession, the League's leaders say minorities are destroying the "Anglo-
Celtic" (white) culture of the South. They oppose most non-white immigration and all
interracial marriages. Founder Michael Hill, a former college professor, has called
blacks "a deadly and compliant underclass" and has embraced well-known white
supremacists such as North Carolina attorney Kirk Lyons.
**Neo-Nazi**: Neo-Nazi groups share a hatred for Jews and a love for Adolf Hitler and Nazi Germany. While they also hate other minorities, homosexuals and even sometimes Christians, they perceive "the Jew" as their cardinal enemy and trace social problems to a Jewish conspiracy that supposedly controls governments, financial institutions, and the media.

While some neo-Nazi groups emphasize simple hatred, others are more focused on the revolutionary creation of a fascist political state. Nazism, of course, has roots in Europe, and links between American and European neo-Nazis are strong and growing stronger. American neo-Nazi groups, protected by the First Amendment, often publish material and host Internet sites that are aimed at European audiences -- materials that would be illegal under European anti-racism laws. Similarly, many European groups put up their Internet sites on American servers to avoid prosecution under the laws of their native countries.

The most important neo-Nazi group in the U.S. is the National Alliance. William Pierce led this group until his death. Pierce was the infamous author of the futuristic race-war novel *The Turner Diaries*, a book believed by some to have served as the blueprint for the 1995 Oklahoma City bombing.

**Racist Skinhead**: Racist Skinheads form a particularly violent element of the white supremacist movement, and have often been referred to as the "shock troops" of the hoped-for revolution. The classic Skinhead look is a shaved head, black Doc Marten boots, jeans with suspenders and an array of typically racist tattoos.

The Skinhead phenomenon began in the industrial cities of 1960s Britain as a working class movement strongly marked by contempt for hippies and middle-class youth. Though drugs and violence were always part of the Skinhead scene, Skinheads originally embraced Afro-Caribbean music and were of different races. But British fascists were able to precipitate a split in the movement between racist and antiracist elements — a split that has endured to the present day, both in Britain and in the United States, where Skins arrived in the early 1980s. Racist Skins are referred to by their enemies as "boneheads;" antiracist Skins are often referred to as SHARPS, a reference to a now essentially defunct group known as Skinheads Against Racial Prejudice.

Racist Skinheads in the U.S., like those in other countries, often operate in small "crews" that move from city to city with some regularity.

**Other**: This category includes hate groups with a hodge-podge of doctrines. Some, like the National Association for the Advancement of White People, are white supremacist groups masquerading as mainstream groups with an interest in issues like black crime, busing and affirmative action. Others embrace racist forms of neo-Pagan religions like Odinism, a pre-Christian theology that is largely focused on the virtues of the tribe or race. This category also includes groups like the Westboro Baptist Church, which singles out homosexuals for hatred.

The Council of Conservative Citizens is a reincarnation of the White Citizens Councils that sprang up in the South in the 1950s and 1960s to oppose school desegregation. Like the League of the South, a neo-confederate group to which it has many links, the
15,000-member Council has tried without success to mask its white supremacist ideology to better promote a right-wing political agenda.

1.3 INTERNATIONAL TERRORISM

*International terrorists* are recognized primarily because of the World Trade Center and Pentagon attacks on September 11, 2001 by anti-American Muslim fundamentalists. *The 9/11 Commission Report issued in July 2004 clearly defines Islamist extremists as the primary international terrorists targeting the United States.*

Islam is one of the world’s three major religions and the fastest growing with over 1 billion Muslims. Followers of the Prophet Mohammed and the Koran, the vast majority of Muslims are peaceful and law-abiding. In fact, many of the tenants, early leaders and prophets, and stories/parables are shared with Christianity and Judaism. Jesus, Moses, Abraham, and the Old Testament are all recognized in Islam and the Prophet Mohammed taught tolerance towards other religions.

However, as with any religion, there are those who either have such extreme beliefs that they feel moved to force others to follow or who would use religion for their own purposes. Islam is no different. There are many different factions of Islam, often depending on which religious leader they follow, what country may provide support, in what country or area they operate, or even which branch of Islam they follow.

Modern (starting about 1950) *Islamism* is the dominant political ideology of Muslim terrorists. Islamism is a group of ideologies in Islam that want to use the *Sharia*, Islamic law, to its full extent, *meaning that secular forms of governments and institutions are considered foreign to a true Muslim society.*

Islamism is not one ideology. Inside the same society, several directions of Islamism can be found, and these are seldom cooperating. However, in general, there are four central motifs to Islamism:

**Differences:** Islamists are strongly concerned with social differences between the rich and the poor worldwide, as well as inside Muslim communities. As responsibility for the poor and the needy is central in Islam, any situation with unevenly divided wealth and many poor people is unacceptable to a zealous Muslim. Islamists react negatively towards both the West for its reluctance to address the poverty of the world, as well as towards the rich in their own societies, who are considered equally reluctant.

**Cultural problems:** Islamists feel that they are losing their culture and that Western clothes, values, social patterns, political structures, language and identity are replacing what once was. Islamists reject many elements of the modern culture (but accept a lot), elements they feel are superfluous and dangerous.

In many countries, the growth of Islamism may moreover be seen in connection with an inferiority complex towards the rich West, which is not only felt by Islamists, but also a majority of Muslims.
The Golden Age: All Muslims are all well aware that they were the superior military and cultural force in the world from the 7th through the 15th centuries and the reversed situation in the modern ages hurts their pride.

Within 100 years of Mohammed’s death in 632 AD, Muslim armies had swept across North Africa, the Middle East, and India, bloodily conquering from the Atlantic almost to the Pacific, and into Spain and France where they were finally stopped at the battle of Poitiers. At that time, the Muslim empire was the largest the world had ever known. They remained in control of Spain until the 15th century, and, under the Ottoman Turks, laid siege to Vienna as late as the 17th century after the fall of Constantinople and occupation of the Balkans in the 15th and 16th centuries.

This military conquest, arising out of Arabia over centuries, was done in the name of religion. As Ibn Khaldun, the great Islamic historian of the 14th century wrote: “In the Muslim community, the holy war is a religious duty, because of the universalism of the Muslim mission and the obligation to convert everybody to Islam either by persuasion or by force.”

Since the fall of the Muslim empire, many Muslim countries have tried to copy the capitalist system, and others the socialist system, but all have seen little beyond marginal success. Islamists are working toward re-establishing a third alternative: the political system that once made their society grow from unknown tribes into world rulers in a few decades.

But in order to achieve this, Islamists are not rejecting modern technology and are very much in favor of implementing technology on a grand scale in Islamist societies. And with the advantages of modern technology, Islamists believe that the coming Islamist society will be an even better society than the one of the Golden Age.

There are no Muslim sources indicating that the Islam of the Golden Age was as strict or as conservative as Islamists believe. Historical research shows that it was a liberal Islam that paved the ground for the cultural, social, and military achievements of those days — values foreign to all major Islamist groups. Hence, there is reason to say that the Islamist idea of the Golden Age is a dramatic falsification of history.

Moreover, the Muslims of the Golden Age were often pragmatic in the sense that they borrowed solutions from other cultures, both from the lands they conquered as well as neighbor states. This is in stark contrast to the current Islamist negative attitudes towards culture and values outside the Muslim world.

Political Alternative: Islamism has been implemented as a real political alternative in modern times. Several countries have implemented Islamist politics: principally Iran, the Taliban in Afghanistan, and Sudan, and also, to some extent, Pakistan and Libya. Saudi Arabia has had Islamist politics for a long time, but is not regarded as Islamist by many, because of the enormous differences between the rich and the poor in that country.

But the large numbers of problems these countries have faced have to a large extent discredited Islamism...what has been represented as good solutions for economy, safety and welfare, has not yielded its promised results.
On a smaller scale, but just as important in many countries, are all the small welfare institutions that Islamists have put up in rural areas and in poor neighborhoods in the cities. These institutions serve people often left out of state run services, like healthcare and support for the unemployed. It is not clear, however, if the Islamists run these from a good heart or because these institutions have proven effective to spread their ideology.

Islamism is a phenomenon primarily manifesting in cities and the most prominent members are young people with higher education, often with a modest background and with parents living in the countryside. Islamists often feel that despite their efforts in their studies, they have not managed to climb much socially and that the jobs they were aspiring for are given to people with good social connections, but less qualifications.

Islamists do not see themselves as revolutionaries in the sense that a revolution will turn the society upside down and create new social structures from scratch. The revolution that Islamists hope for is the one that will bring old values back (according to how they believe that society was in early Islam) and wipe out all degenerated elements in the modern society. But Islamism is just as much a fight against what they perceive as old, rigid values, still found among many Muslims living in rural areas. Islamists seek to bring people of the rural areas into the modern age, at the same time as they fight for preserving many old values that they believe that cities dwellers are losing.

Islamists' political programs were for a long time simple and basic: everything should be based on the Sharia. But demands from rulers and intellectuals have forced the Islamists to "concretize" the actual content in their politics. Sayyid Qutb (an Egyptian and one of the main characters of Sunni Islamism who is the direct antecedent to Osama bin Laden and Al Qaeda) stated that this content would be clarified through the practice of Islamism. This implies that the Sharia was not clear on all points and that man had to base his decisions on more sources than just it.

Qutb played a key role as the source of these ideas behind political Islam and particularly Al Qaeda. A teacher and writer in Egypt, Qtub drifted from nationalist opposition to the British into political Islam and left an extensive set of writings that set the agenda for Islamism. He argued that man had compromised the sovereignty of God, and Muslims accordingly must form a vanguard to conduct jihad. He defined the "greater jihad" as the struggle against one’s own impurity and base desires, while the "lesser jihad" is for the expansion of Islam. Qutb stressed both of these in justifying rebellion against Muslim and foreign governments. He had studied in the United States, and his view of the West amounts to a form of Occidentalism that relentlessly criticized America as a polar opposite of Islam.

As for economic policies, most Islamists defend a system close to the social democracy practiced in many European countries. When Islamists diverge from social democracy, it is more often in a direction of capitalism than in direction of communism. (The most specific Islamist view on economics is the refusal to pay interest on loans and deposits. Instead banks should work as investment organization, earning money from real profits. There have been attempts on establishing such bank systems, but the results have in some cases been catastrophic, as was the case in Egypt in the 1980's.)

Islamists are not believers in democracy. But, Islamist programs are not in favor of dictatorship (even if this has been the temporary result of Islamism in Iran and Sudan). The ideal structure in an Islamist society is the system of shura, in which the leaders are in frequent contact with
the entire society; ask about their needs and their ideas; and are obliged to show respect for what they are told. **Unfortunately, Islamists have shown little ability to define structures that will prevent the leaders inside the shura system from turning it into a system of dictatorship.**

Islamists are at the heart of international terrorism. The reason for resorting to violence appears to be the same over and over again: first, the Islamists try to change the rulers and men of power through intellectual means, but as this seldom leads to anything and as there seldom are any democratic channels to be used, violence has been the last resort. **But, during the last two decades, violence has become an intrinsic part of the Islamist ideology and the will to use violence doesn't need much provocation anymore.**

Added to the religious and political mix of Islamism is the "thorn" represented by the State of Israel.

Historically, Jews from around the world, but mostly from Europe, began to return to their Biblical homeland in the 1880's, buying land in Palestine from Ottoman Empire owners. Pressure for a Jewish "homeland" grew during and after the First World War and this pressure became insurmountable after the Second World War, in part due to the horror and guilt over the Holocaust (which many Islamists simply deny occurred). Mandated by the UN in 1947, Palestine was divided into two states: one Jewish and one Arab.

The predominately Muslim Arab world rejected the 1947 UN mandate and has, since 1948, been trying to eliminate Israel as a nation. **While Egypt and Jordan (and even the Palestine Liberation Organization) have signed agreements with Israel recognizing its right to exist, the vast majority of Arab Muslims and all Islamists reject that position out of hand.** This hatred of Israel, and by extension, hatred of its chief supporter and ally, the United States, is based on several factors:

**Religious Intolerance:** Most Muslims see a non-Muslim state, no matter how small, in the midst of the 21 Muslim Arab nations, as an unacceptable affront to their religion.

**Western Influences:** Israel is predominately a Western nation with most of the Western secular political and cultural aspects that are considered by Islamists to be decadent and despoiling.

**Economic Success:** Israel has had great economic success while most of the Muslim Arab nations have not. If it were not for oil, all of the Arab nations would be as poverty-stricken as the ones that have no appreciable oil reserves.

**Palestinian Refugees:** When Israel was created, and with later expansions after the 1967 and 1973 wars, large numbers of Muslim Arabs living in the country were displaced. These refugees and their descendents maintain a constant pressure on their fellow Arabs to help them reclaim their lost land. In the interim, these refugees present significant economic, political, and cultural problems for their host nations.

(The Palestinian narrative of their refugee problem conveniently omits that the displacement of Palestine's Arabs took place during a war the Arabs started. And the Palestinians studiously avoid discussion of their war aims in that conflict, articulated by Arab League Secretary General Azzam Pasha in May 1948: "This will be a war of extermination and a momentous massacre that will be spoken of like the Mongolian massacres and the Crusades.")

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While subnational groups, not by the army of a country, carry out most international terrorist acts, the U.S. has identified 12 countries, including Cuba, Iran, North Korea, Sudan, Syria, and Libya, as "state sponsors" of international terrorism. These countries provide funding, resources, and refuge that places international terrorists on a significantly enhanced operating plane when compared to domestic terrorist groups. These countries support and use terrorism for a variety of reasons:

1. Most of these countries do not have a strong record on human rights or personal freedom. Often dissidents will come to the US and take advantage of our open society to speak out against a particular regime. Some countries have threatened, attacked, and even assassinated dissidents here in the US.

2. Many smaller, less powerful and less wealthy countries see terrorism as another tool in the projection of military, diplomatic, financial, and economic power.

3. A country may use terrorism as revenge for some actual or perceived injustice. A number of terrorist attacks have been in retaliation for some negative action we have taken in towards another country.

4. Finally, none of these countries can stand toe-to-toe with the US in a conventional war. This is the poor man's way to wage war.

Finally, without a doubt, the architects and engineers who designed the Murrah Federal office building in Oklahoma City, the World Trade Center, the Pentagon, and even the McDonald's in Tucson did not envision that these facilities would be attacked by terrorists and certainly did not include "antiterrorism" as a building design criteria. Today, however, terrorism (or at least the potential of terrorism) directed toward buildings is common enough that every designer must consider design elements that help mitigate these attacks.
ARE YOU A TARGET?
THREATS AND RISK ASSESSMENT

"A danger foreseen is half avoided"
- Thomas Fuller

2.1 TERRORIST THREATS

Mitigating the threat of terrorist attacks against an occupied building is a challenging task. It is difficult, if not impossible, to predict who, why, when, or how terrorists may attack. But looking at the history of terrorism over the last 30 years, especially in the Middle East and Europe, certain patterns are found to apply to help the building owner and designer define potential terrorist threats.

Buildings are primarily susceptible to three types of terrorist threats:

1. **Manned Attack**: Both standoff attacks with aggressors using ballistic weapons (handguns, rifles, machine guns, grenades, Molotov cocktails, etc.) and armed aggressors entering (or attempting to enter) the building must be considered.

2. **Explosives**: External or internal bombs or mines, including arson. The potential for external explosive must be considered, even if the building being designed is low risk itself, but is located close to a high-risk facility.

3. **Chemical, biological, or radiological (CBR) weapons**: Introducing CBR agents into air supplies or water supplies, or the release of onsite hazardous materials during a penetration attack or by an employee.

Comprehensive protection against the full range of possible threats is prohibitively costly, and probably not even possible. *However, a level of protection that reduces the risk of mass casualties resulting from terrorist attacks can be provided for all occupants of the buildings we design.*

**Manned Attack**: Attack by armed terrorist groups can be "standoff", i.e., the attackers remain at or beyond the perimeter of the building site and use small arms, hand-thrown or rocket-
propelled grenades, Molotov cocktails, or even mortars to attack the building and people entering or leaving it. A "penetration attack" may also be launched with the goal of entering the building to damage property (general or targeted); kidnap individuals or groups of people or to take hostages; fire-bomb the facility; theft; or plant covert surveillance devices.

Structure hardening required to offset typical manned attack weapons is summarized in the following table:

<table>
<thead>
<tr>
<th>Representative Ballistics Round</th>
<th>Cast in Place Concrete</th>
<th>Solid Concrete Blocks</th>
<th>Brick</th>
<th>Mild Steel Plate</th>
<th>Hardened Steel Plate</th>
<th>Bullet Resistant Fiberglass</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 mm or 38 cal.</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1/4</td>
<td>3/16</td>
<td>5/16</td>
</tr>
<tr>
<td>44 magnum</td>
<td>2.5</td>
<td>4</td>
<td>4</td>
<td>5/16</td>
<td>1/4</td>
<td>7/16</td>
</tr>
<tr>
<td>7.62 mm or 30 cal rifle</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>9/16</td>
<td>7/16</td>
<td>1-1/8</td>
</tr>
<tr>
<td>7.62 mm armor-piercing round (rifle)</td>
<td>6.5</td>
<td>8</td>
<td>8</td>
<td>13/16</td>
<td>11/16</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Explosives:** Terrorists are making bombs more compact and harder to detect. As buildings have become prime targets, bombs have become larger. The World Trade Center parking garage bomb had the explosive power of about 2,000 pounds of TNT. The bomb that destroyed the Murrah Federal Building in Oklahoma City had the power of about 4,800 pounds of TNT. The truck bomb that destroyed the Al Khobar Towers building near Dhahran, Saudi Arabia, has been estimated to have been equivalent to between 20,000 and 30,000 pounds of TNT.

The following table summarizes vehicles and their general delivery capabilities in pounds of TNT and the amount of atmospheric overpressure produced by the resulting explosion:

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Typical TNT Charge (lb)</th>
<th>Explosion Overpressure (psig)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At 30 ft.</td>
</tr>
<tr>
<td>Compact car trunk</td>
<td>250</td>
<td>182</td>
</tr>
<tr>
<td>Standard car trunk</td>
<td>500</td>
<td>367</td>
</tr>
<tr>
<td>Panel van</td>
<td>1,500</td>
<td>1,063</td>
</tr>
<tr>
<td>Box truck</td>
<td>5,000</td>
<td>2,900</td>
</tr>
<tr>
<td>Single tractor-trailer</td>
<td>30,000</td>
<td>9,290</td>
</tr>
<tr>
<td>Double tractor-trailer</td>
<td>60,000</td>
<td>13,760</td>
</tr>
</tbody>
</table>

Ironically, antiterrorism design measures that push protective perimeters further away from otherwise vulnerable buildings (see Section 3.1) may cause terrorists to turn to still larger bombs (now typically car and truck bombs) meant to kill as many people as possible.

Adult humans can withstand only about 30-40 psig overpressure before the lungs collapse. Death is certain at 100-120 psig overpressure. Overpressures as low as 10 psig can be fatal to children and the elderly.
Building damage from blast overpressure can range from significant to catastrophic as illustrated by the following table:

<table>
<thead>
<tr>
<th>Damage</th>
<th>Explosion Overpressure (psig)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard window glass breakage</td>
<td>0.15-0.22</td>
</tr>
<tr>
<td>Minor damage to almost all buildings</td>
<td>0.5-1.1</td>
</tr>
<tr>
<td>Panels of sheet metal buckled</td>
<td>1.1-1.8</td>
</tr>
<tr>
<td>Failure of concrete masonry unit (CMU) walls</td>
<td>1.8-2.9</td>
</tr>
<tr>
<td>Collapse of wood framed buildings</td>
<td>5-6</td>
</tr>
<tr>
<td>Serious damage to steel framed buildings</td>
<td>4-7</td>
</tr>
<tr>
<td>Severe damage to reinforced concrete structures</td>
<td>6-9</td>
</tr>
<tr>
<td>Total destruction of most buildings</td>
<td>10-12</td>
</tr>
</tbody>
</table>

Another bomber tactic, especially aimed at security personnel, is the use of two devices placed close to each other with the second device timed to go off a few minutes after the first. The first explosion is intended to attract security personnel to the scene; the second is intended to injure or kill them. This tactic has been used by Islamist terrorists in Israel and by the Provisional Irish Republican Army (PIRA) in Northern Ireland and the United Kingdom. It was used for the first time in the United States in January, 1997 at an Atlanta abortion clinic bombing.

More troubling still is that terrorists, both international and domestic, have access to a wider range of explosives (and other weapons) than at any time in the past.

Explosive materials are designed to release a large amount of energy in a very short time. Part of the energy is released as heat and part as shock waves that travel through the air and the ground. As illustrated by the following figure, the shock wave (air blast) radiates at supersonic speed in all directions from the explosive source, diminishing in intensity as the distance from the source increases. With an external bomb release, these waves reflect off the ground, adjacent structures, and other surfaces, reinforcing the intensity of the blast’s effects. These reflections are most pronounced in dense urban environments where neighboring structures can create a canyon effect or where pockets of blast energy can become trapped in re-entrant (concave) corners.
The blast pressures experienced by a structure are related to the amount of explosive used and the distance of the building from the explosion. The peak incident pressure, charge weight, and distance are mathematically related through an expression that varies as a linear function of the weight of the explosive and cube function of the distance from the center of the explosion.

Once the blast wave enters occupied spaces or, with an internal explosion, the pressure wave is reflected off walls, floors, and ceiling, it forms in effect a series of pressure pulses. The response of the ears and lungs to repetitive pulses is similar to the response to a single long pulse. Because the damaging effects of blast pressure indoors often exceed those of an unconfined explosion of similar size, it is crucial to minimize the opportunity for blast pressures from outdoor explosions to enter occupied spaces and to protect such spaces from even small explosive devices.

In addition to the direct blast overpressure effects, individuals within structures subjected to blast effects, penetration by glass fragments and impact by other blast-induced debris have been consistent causes of death and serious injury. People are also subject to blunt trauma from furniture, accessories, and nonstructural building components like overhead lighting and ductwork that become detached from their moorings. Smoke and inhalation of dust also cause blast-induced injury.

**CBR Weapons:** CBR threats consist of chemical, biological, and radiological weapons that can be introduced into a building. There are five basic types of CBR agents that must be considered:

1. Classic chemical warfare agents commonly exist as either a gas or liquid aerosol. Many of the blister and nerve agents, having low vapor pressures, are delivered as a liquid aerosol; while many other higher vapor pressure agents are gaseous. Blister agents, also known as vesicants, include sulfur and nitrogen mustards, as well as a
variety of arsenic-containing materials. Blister agents tend to have relatively low volatility and modest acute toxicity compared to other chemical warfare agents. Blood and choking agents are highly volatile inhalation hazards. Blood agents include hydrogen cyanide (AC), cyanogen chloride (CK), and arsine (SA). Choking agents include phosgene (CG) and diphosgene (DP). Nerve agents are derivatives of organophosphate esters and are among the most toxic chemicals known. This class includes materials such as O-ethyl-S-(2-diisopropyl aminoethyl) methyl phosphonothiolate (VX), ethyl N,N-dimethyl phosphoroamido cyanide (tabun), isopropyl methylphosphonofluoridate (sarin), and pinacolyl methyl phosphonofluoridate (soman). Nerve agents have a wide range of volatilities and their toxicity is approximately 100 times higher than blood and choking agents. Incapacitating agents are usually distinguished from riot-control agents by their longer period of effectiveness, which may be as long as days after exposure. Examples of incapacitating agents include 3-quinuclidinyl benzilate (BZ), cannabinoids, phenothiazines, fentanyl, and central nervous system stimulants, i.e., d-lysergic acid diethyl amide (LSD).

2. Toxic industrial chemicals (TIC’s) and toxic industrial materials (TIM’s) are commonly categorized by their hazardous properties, such as reactivity, stability, combustibility, corrosiveness, ability to oxidize other materials, and radioactivity. Gaseous agents can be divided into the following categories: organic vapors (i.e., cyclohexane), acid gases (i.e., hydrogen sulfide), base gases (i.e., ammonia), and specialty chemicals (i.e., formaldehyde or phosgene). TIC’s that have a combination of high toxicity and ready availability are of principal concern. Those having a volatility of less than 10 torr at room temperature are effectively removed by physical adsorption. However, a number of high toxicity TIC’s, produced industrially on a large scale, have volatilities higher than 10 torr at 20°C and are more difficult to collect.

3. Biological agents such as Bacillus anthracis (anthrax), Variola major (smallpox), Yersinia pestis (bubonic plague), Brucella suis (brucellosis), Francisella tularensis (tularemia), Coxiella burnetti (Q fever), Clostridium botulinum (botulism toxin), viral hemorrhagic fever agents, and others have the potential for use in a terrorist attack. Each of these biological agents may travel through the air as an aerosol. Generally, viruses are the smallest, while bacteria and spores are larger. In nature, biological agents and other aerosols often collide to form larger particles; however, terrorists or other groups may modify these agents in ways that reduce the occurrence of this phenomenon, thus, increasing the number of biological agents that may potentially be inhaled. There are significant differences from one agent to another in their adverse public health impact and the mass casualties they can inflict. An agent’s infectivity, toxicity, stability as an aerosol, ability to be dispersed, and concentration all influence the extent of the hazard. Other important factors include person-to-person agent communicability and treatment difficulty.

4. Toxin agents include bacterial (exotoxins and endotoxins), algae (blue-green algae and dinoflagellates), mycotoxins (trichotheones and aflatoxins), botulinum, and plant- and animal-derived toxins. Toxins form an extremely diverse category of materials and are typically most effectively introduced into the body by inhalation of an aerosol. They are much more toxic than chemical agents. Their persistency is determined by their stability in water and exposure to heat or direct solar radiation.

5. Radiological hazards can be divided into three general forms: alpha, beta, and gamma radiation. These three forms of radiation are emitted by radioisotopes that may
occur as an aerosol, be carried on particulate matter, or occur in a gaseous state. Alpha particles, consisting of two neutrons and two protons, are the least penetrating and the most ionizing form. Alpha particles are emitted from the nucleus of radioactive atoms and transfer their energy at very short distances. Alpha particles are readily shielded by paper or skin and are most dangerous when inhaled and deposited in the respiratory tract. Beta particles are negatively charged particles emitted from the nucleus of radioactive atoms. Beta particles are more penetrating than alpha particles, presenting an internal exposure hazard. They can penetrate the skin and cause burns. If they contact a high-density material, they may generate X-rays, also known as Bremmstrahlung radiation. Gamma rays are emitted from the nucleus of an atom during radioactive decay. Gamma radiation can cause ionization in materials and biological damage to human tissues, presenting an external radiation hazard. There are three primary scenarios in which radioactive materials could potentially be dispersed by a terrorist: (1) conventional explosives or other means to spread radioactive materials (a dirty bomb), (2) attack on a fixed nuclear facility, and (3) nuclear weapon.

There are three basic scenarios for delivery of CBR agents:

- Large scale, external, airborne release targeting a broad area.
- External airborne release close to and targeted at a specific building (e.g., individual outdoor air intakes, etc.)
- Internal airborne release, typically delivered by mail or parcel service, through a purposeful release during a manned attack, or by an employee is possible. Another internal source of CBR agents may be hazardous materials stored onsite.

While many have forecasted that CBR weapon attacks represent serious potential for terrorist attack, calmer heads are pointing out the practical limitations on these types of weapons. In general, the potential for a CBR attack resulting in large numbers of casualties is very low.

To manufacture CBR agents, expert opinion suggests that graduate-level organic chemistry training is necessary for the manufacture of nerve agents and most other chemical weapons...there is little potential danger from a high school graduate working in his garage (except, perhaps, to the terrorist himself). The technical challenges to making nerve agents are significant and, while not insurmountable, would be difficult manage without a high level of education and training.

Biohazard weapons are even more difficult to isolate and control. A Class 4 laboratory would be required for most such activities, and the skill levels required of the developers are very high, much higher than would be expected of a typical terrorism organization.

Delivery of CBR weapons is another consideration. Studies show that Sarin, the nerve gas used by the Aum Shinrikyo cult in the Tokyo subway, delivered by outdoor release would require the following:

- 22 lbs of Sarin is required to kill about 50 people
- 220 lbs of Sarin is required to kill 500 people
- 2,200 lbs of Sarin is required to kill 5000 people
This represents a great deal of agent per person, making manufacture, transport, and delivery very difficult. Obviously, though, the amount of Sarin required to kill in an enclosed environment is much lower: the Tokyo subway attack in March 1995 produced over 3,000 casualties and 12 deaths from five small canisters of impure Sarin released in five different railroad cars.

Biological agents, once released outdoors, travel great distances. Since these agents are sensitive to sunlight, humidity, temperature, exposure to oxygen (oxidation), and other pollutants in the air, their lethal capacities rapidly degrade during this travel. Most biological agents lose their virulence at the rate of 10-30% per minute and thus, represent only a short-term potential hazard. Even releasing these agents into a building's ventilating system would affect only that portion of the building served by that system (see Chapter 6) since few HVAC systems serve entire buildings unless they are very small.

Release into water supplies is also a potential delivery method for CBR agents. Many large water systems in the U.S. were built more than 50 years ago when the threat of bioterrorism was not on the horizon. These systems were not built with security in mind, yet their size may be their best defense against deliberate contamination by a terrorist. San Francisco, for example, receives part of its drinking water supply from the Crystal Springs Reservoir south of the city. Assuming perfect dilution, poisoning this reservoir with sufficient hydrogen cyanide to cause death or debilitation to someone consuming one glass of water would require over 400,000 metric tons of the toxin (according to a U.S. Air Force estimate).

Many smaller reservoirs exist, and some contaminants can be dangerous in lower concentrations. But, even the most committed terrorist would struggle to obtain and deliver the volume of toxin required to contaminate an entire reservoir or aqueduct.

To help protect water supplies, the US Bioterrorism Act of 2002 requires that owners and operators of municipal or community water systems serving more than 3300 people do the following:

- Identify potential threats to the water system;
- Assess the water system's vulnerabilities;
- Evaluate the likelihood and consequences of an attack on the system; and
- Implement upgrades to the water system to increase security.

However, since the Act did not include a funding element, local governments and private water system owners see these requirements as an "unfunded mandate" and progress toward compliance has been slow.

Experts agree that if attacks occur at all, they are more likely to focus on very small systems, including individual sites or small parts of larger systems. While it may be impossible to poison the entire water supply of San Francisco, it may be conceivable to poison one tank of treated San Francisco water or the entire system serving a remote desert truck stop or isolated ski resort. Not only are the volumes of toxin required more manageable for a terrorist, but security protection may be weak or nonexistent. In this case, the safety of consumers relies almost entirely on the chlorine used to treat potable water supplies.

Residual chlorine in the holding tanks is the most significant remaining defense against contaminants. While chlorine may be ineffective against chemical toxins, there are some
biological toxins and pathogens against which it is effective. Cholera and the botulinum toxin that causes botulism can be inactivated by chlorine exposure.

Other biological agents, however, are resistant to chlorine and the resistance of others is unknown. Anthrax spores are resistant to chlorine and can remain stable in water for two years. The resistance of other possible bioterrorism agents such as plague and brucellosis is unknown. Even biological agents that are not resistant to chlorine can be a threat if terrorists can infiltrate a treatment plant and deactivate the chlorinating system.

While tanks could be vulnerable, pipes downstream from the treatment plant also are vulnerable. Fortunately the high pressure contained in pipes makes injecting a contaminant difficult, but the relative lack of security could make this an easier target than a finished water tank. Monitoring every accessible pipe continuously is impossible for most water utilities, so again we must rely primarily on residual chlorine. Ensuring that manholes are secure and that tanks are covered and locked may be the most significant measure a water system can take to prevent this danger in the short term.

2.2 THREAT ASSESSMENT

For private sector commercial, industrial, and institutional facilities, there are few threats that can be directly and quantitatively identified. However, a broad description of potential private sector targets has been developed:

1. If a building is an "icon," such as the World Trade Center in New York, the Sears Tower in Chicago, the Bank of America Building in San Francisco, etc., or is symbolic in some way, it is an obvious target for terrorists.

2. Research facilities, especially those involving animals, may be targets for environmental and/or animal rights terrorists. Even restaurants, abattoirs, meat processing plants, etc. have been the targets of the ALF.

3. Convention centers; sports stadiums; theaters and performing arts centers; museums; shopping centers; schools; and other facilities that, at any point in time, may house a large population, can be targets. Even an area or district can be a target, such as nightclub or restaurant district in a city or an industrial zone that may contain large quantities of hazardous materials, etc.

4. Facilities that may host potentially politically charged gatherings such as a world banking conference, biotechnology conferences, family planning and/or population control meetings, etc. can be at risk.

5. Transportation centers, primarily because of the large populations that use these centers, are always at risk.

6. Industrial facilities that deal with hazardous materials, especially such facilities owned by large, multi-national corporations can be targets. (Note that problems a manufacturer may have in one country may make all of the manufacturer's facilities worldwide potential targets. Some other specific businesses, such as banks, fall into this same category.)
7. Commercial office buildings that house government offices as tenants, especially if the tenant is the FBI, DEA, Homeland Security, Immigration, or other potentially unpopular agency (particularly the IRS).

8. Non-building facilities, such as pipelines; bridges and tunnels; electric power substations and generators (especially nuclear); telecommunications infrastructure; etc. can be considered desirable targets by a terrorist. Locating a building close to these facilities may put the building at risk.

9. Finally, any facility located close to a government facility or one of the types of targets listed above may be at risk even though it does not fit into any of these categories; collateral damage must always be considered. (Against the advice of security consultants, the New York City Office of Emergency Management placed its Emergency Operations Center (EOC) in 7 World Trade Center, next door to the highest-profile terrorist target of all time. The EOC was destroyed during the very kind of emergency it was designed to handle!)

Buildings that do not fit into any of these categories may be considered "lower risk", but a threat assessment should be done for every new building designed. This assessment must include input from the building owner, particularly the owner’s security team; past threats from disgruntled customers or employees may be indicative of larger problems. If the owner operates overseas, are there any issues that impact here? If the building was attacked, is there a great potential to inflict significant emotional and/or economic damage? Interface with state and local police and security agencies is required. In many areas of the country there are threat-coordinating committees that facilitate the sharing of information.

2.3 VULNERABILITY AND RISK

The next step is to evaluate the building’s potential vulnerability to threat(s) and to determine whether measures are required to mitigate potential threats. In other words, an assessment of the particular building’s ranking as a potential target from the terrorist viewpoint is required. An assessment methodology modeled after one developed by the US Department of Justice, Office of Justice Programs, seems to provide an objective approach to evaluating buildings in the private sector, as follows:

1. **Level of visibility** defines the perceived awareness of the building’s existence and the visibility of the building to the general population and, thus, a terrorist. The level of visibility can be ranked as follows:
### Level of Visibility

<table>
<thead>
<tr>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invisible…the building location is well hidden.</td>
<td>0</td>
</tr>
<tr>
<td>Very low visibility…obscure or remote location, no architectural flair, well-screened from surroundings, etc., little local traffic…probably not aware of existence</td>
<td>1</td>
</tr>
<tr>
<td>Low visibility…no architectural flair, well-screened from surroundings, etc., little local traffic…existence probably not well known</td>
<td>2</td>
</tr>
<tr>
<td>Medium visibility…typical facility, some architectural elements, signage, etc., some local traffic…existence probably known.</td>
<td>3</td>
</tr>
<tr>
<td>High visibility…existence is well known, prominently displayed, signage, significant local traffic.</td>
<td>4</td>
</tr>
<tr>
<td>Very high visibility…existence is obvious, in the news, significant local traffic, etc.</td>
<td>5</td>
</tr>
</tbody>
</table>

2. **Asset value** is a qualitative appraisal of the value and usefulness of the facility. How important is the building in terms of replacement cost and what how would the loss or significant damage to the facility impact the local economy or population, the owner, etc.? What effect would the loss or significant damage to the facility have on continuity of operations, emergency response, or other potential consequences? The relative asset value can be defined as follows:

<table>
<thead>
<tr>
<th>Asset Value</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little or no value…loss would have no impact</td>
<td>0</td>
</tr>
<tr>
<td>Minor value…loss would minimum impact</td>
<td>1</td>
</tr>
<tr>
<td>Moderate value…the facility has moderate value to the owner and the impact of loss or significant damage, while manageable, would be felt.</td>
<td>2</td>
</tr>
<tr>
<td>Significant value…the facility has significant value to the owner and the impact of loss or significant damage would be significant.</td>
<td>3</td>
</tr>
<tr>
<td>High value…the facility has significant value to the owner and the loss or significant damage would have a major impact.</td>
<td>4</td>
</tr>
<tr>
<td>Critical…the facility is unique and its loss or significant damage would have both a significant and a long-term negative impact.</td>
<td>5</td>
</tr>
</tbody>
</table>

3. **Potential value to a terrorist**'s political, religious, racial, environmental, or special interest goals is a subjective appraisal of the facility's importance to terrorists. In other words, what "message" is sent by the destruction or significant damage to the facility? For example, destruction of an animal research facility has great message potential for the ALF, while destruction of a branch bank would not. The potential value to a terrorist can be categorized as follows:
<table>
<thead>
<tr>
<th>Potential Value to Terrorist</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little or no value</td>
<td>0</td>
</tr>
<tr>
<td>Minor value</td>
<td>1</td>
</tr>
<tr>
<td>Moderate value</td>
<td>2</td>
</tr>
<tr>
<td>Significant value</td>
<td>3</td>
</tr>
<tr>
<td>High value</td>
<td>4</td>
</tr>
<tr>
<td>Very high value</td>
<td>5</td>
</tr>
</tbody>
</table>

4. *Access to the facility* is a measure of the "openness" of the facility and, thus, the ease for ingress and egress by a potential terrorist. Access to the facility can be categorized as follows:

<table>
<thead>
<tr>
<th>Access to the Facility</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility is fully fenced and guarded; controlled access by pass only; no vehicle parking within minimum standoff distances; etc.</td>
<td>0</td>
</tr>
<tr>
<td>Facility is not fenced (or only partially fenced) but is guarded; controlled access of visitors and non-staff personnel; no vehicle parking within minimum standoff distances; etc.</td>
<td>1</td>
</tr>
<tr>
<td>Facility has controlled access of visitors and non-staff personnel; no vehicle parking within minimum standoff distances; etc.</td>
<td>2</td>
</tr>
<tr>
<td>Facility has controlled access of visitors and non-staff personnel; no unauthorized vehicle parking within minimum standoff distances; etc.</td>
<td>3</td>
</tr>
<tr>
<td>Open access by visitors and non-staff personnel; no vehicle parking within minimum standoff distances; etc.</td>
<td>4</td>
</tr>
<tr>
<td>Open access by visitors and non-staff personnel; no limits on vehicle parking; etc.</td>
<td>5</td>
</tr>
</tbody>
</table>

5. *Hazardous materials threat* is a measure of the potential release of CBR materials. Are CBR materials present in quantities that could become hazardous if released? These CBR materials may be onsite or in close proximity so that an accidental or purposeful release would be hazardous to the facility and its occupants. Take into account the distance from the building that materials are stored (usually a 1 mile radius is considered maximum); the prevailing wind directions; the slope of the terrain (upslope is much better than down slope); and the quantity and types of materials present. The relative hazardous materials threat can be defined as follows:
### Asset Value Score

<table>
<thead>
<tr>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>No CBR materials onsite or relatively nearby</td>
<td>0</td>
</tr>
<tr>
<td>CBR materials present in moderate quantities, but under positive control in secured locations</td>
<td>1</td>
</tr>
<tr>
<td>CBR materials present in moderate quantities, but with access and use controls in place</td>
<td>2</td>
</tr>
<tr>
<td>Large quantities of CBR materials onsite or relatively nearby, but under positive control in secured locations</td>
<td>3</td>
</tr>
<tr>
<td>Major quantities of CBR materials onsite or relatively nearby with moderate control features</td>
<td>4</td>
</tr>
<tr>
<td>Major quantities of CBR materials onsite or relatively nearby that are accessible to visitors and/or non-staff personnel</td>
<td>5</td>
</tr>
</tbody>
</table>

6. *Facility population* is a key measure that can be categorized as follows:

<table>
<thead>
<tr>
<th>Maximum Facility Population</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1-250</td>
<td>1</td>
</tr>
<tr>
<td>251-500</td>
<td>2</td>
</tr>
<tr>
<td>501-1,000</td>
<td>3</td>
</tr>
<tr>
<td>1,001-5,000</td>
<td>4</td>
</tr>
<tr>
<td>5,001 +</td>
<td>5</td>
</tr>
</tbody>
</table>

7. *Potential for collateral damage* is a subjective estimate of the number of people within a 1-mile radius of the facility who may be injured or killed as result of an explosive or CBR attack on a facility. This measure is categorized as follows:

<table>
<thead>
<tr>
<th>Maximum Potential for Collateral Damage (Population)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-100</td>
<td>0</td>
</tr>
<tr>
<td>100-500</td>
<td>1</td>
</tr>
<tr>
<td>501-1,000</td>
<td>2</td>
</tr>
<tr>
<td>1,001-2,000</td>
<td>3</td>
</tr>
<tr>
<td>2,001-5,000</td>
<td>4</td>
</tr>
<tr>
<td>5,001 +</td>
<td>5</td>
</tr>
</tbody>
</table>

The total score for any facility, based on these seven factors, will range from 0 to 35. A facility with a total score less than 10 is, in all probability, a low threat risk and would warrant only basic terrorist mitigation measures incorporated into the design. Any facility with a score of 25 or greater should be considered a higher threat risk and significant mitigation measures must be considered. Buildings with scores between 11 and 24 have increasing threat risk and mitigation measures must be evaluated on a case-by-case basis using cost-benefit analysis techniques.


2.4 TERRORISM INSURANCE

For non-commercial facilities, conventional current insurance coverage can extend to terrorist attacks as follows:

Standard homeowners insurance policies include coverage for damage to property and personal possessions resulting from acts of terrorism. Terrorism is not specifically referenced in homeowner's policies; however, the policy does cover the homeowner for damage due to explosion, fire and smoke - the likely causes of damage in a terrorist attack.

Condominium or co-op owner policies also provide coverage for damage to personal possessions resulting from acts of terrorism. Damage to the common areas of a building like the roof, basement, elevator, boiler and walkways would only be covered if the condo/co-op board has purchased terrorism coverage.

Standard renters’ policies include coverage for damage to personal possessions due to a terrorist attack. Again, the property owner or landlord must purchase coverage for the apartment complex itself.

Automobile insurance policies will cover a car that is damaged or destroyed in a terrorist attack only if the policyholder has purchased “comprehensive” coverage. Lenders and leasing companies require most people who have vehicle loans or lease a vehicle to carry this optional form of coverage. People who buy liability coverage only are not covered in the event their vehicle is damaged or destroyed as the result of a terrorist attack.

Life insurance policies do not contain terrorism exclusions. Proceeds will be paid to the beneficiary as designated on the policy.

Prior to 9/11, standard commercial insurance policies included terrorism coverage as part of the package, effectively free of charge. However, immediately afterward, insurance providers began to include “terrorist attack” exclusions in commercial policies.

To address this problem, on November 26, 2002, Congress approved the Terrorism Risk and Insurance Act (TRIA), which (1) nullified the terrorism exclusions in commercial property and professional liability insurance and (2) made available $100 billion in federal funds to cover losses from terrorist attack.

TRIA was initially enacted to guarantee the availability of terrorism insurance coverage with the expectation that a private, market-based solution would develop. Insurers, however, have argued that terrorism insurance is unpredictable and financially impractical without federal assistance. Indeed, some commercial property-casualty policies included a caveat that if TRIA lapsed on December 31, 2005, the insurer would no longer provide terrorism coverage. Since some lenders will not lend to commercial real estate projects without terrorism insurance, the fear was that TRIA’s lapse would halt many current and future development projects.

TRIA was scheduled to expire on December 31, 2005 and a report issued by the US Treasury in the summer of 2005 recommended against extending TRIA. The Bush administration also issued notice that it opposed extension. But, in November 2005, Congress voted for a modified 2-year extension to TRIA, to December 31, 2007.
The new law contained a provision increasing TRIA’s activation level from $5 million to $50 million in 2006, and then to $100 million in 2007. Other stipulations include the increase in deductibles and co-payments, which will augment the insurance industry’s responsibility; the repayment of 25 percent of federal aid for payments in 2006 and 27.5 percent for 2007 payments; and the creation of a “President’s Working Group on Financial Markets,” which is charged with developing long-term solutions to supplant TRIA.

[2010 Update: President George W. Bush signed the Terrorism Risk Insurance Program Reauthorization Act of 2007 (the Act) on December 26, 2007. Several provisions of the initial Act have changed in the 2007 extension, including:

- Revising the definition of a certified act of terrorism to eliminate the requirement that the individual(s) are acting on behalf of any foreign person or foreign interest.
- Extending the program by seven years through December 31, 2014.
- Requiring clear and conspicuous notice to policyholders of the existence of the $100 billion cap.
- Fixing the Insurer Deductible at 20% of an insurer’s direct earned premium, and the federal share of compensation at 85% of insured losses that exceed insurer deductibles.
- Fixing the program trigger at $100 million for all additional program years.
- Requiring the U.S. Treasury to promulgate regulations for determining pro-rata shares of insured losses under the program when insured losses exceed $100 billion.
- Requiring the Comptroller General to study the availability and affordability of insurance coverage for losses caused by terrorist attacks involving nuclear, biological, chemical, or radiological materials and issue a report not later than one year after the enactment of the Terrorism Risk Insurance Program Reauthorization Act of 2007.
- Requiring the Comptroller General to determine whether there are specific markets in the United States where there are unique capacity constraints on the amount of terrorism insurance available and issue a report not later than 180 days after the enactment of the Terrorism Risk Insurance Program Reauthorization Act of 2007.
- Requiring the President’s Working Group on Financial Markets to continue an ongoing study of the long-term availability and affordability of terrorism risk insurance.
- Accelerating the timing of the mandatory recoupment of the federal share through policyholders surcharges.
- In the absence of private market innovations and solutions, sustaining a viable private market for terrorism insurance depends on a federal backstop.

However, there have been few terror incidents in the United States since 2001 and a recent survey concludes that more than 80 percent of reinsurers are actively seeking new or expanded terror insurance business. Despite the heightened interest from reinsurers and an expanded range of underwriting options, purchases of standalone terror coverages have decreased,
underscoring an imbalance between supply and demand in the marketplace. *At the moment then, it is a buyers market relative to terror insurance.*

But, a number of factors could result in a substantially tighter market for terrorism cover in the near future. These include a major terrorist attack, as well as the Obama Administration’s proposed cut in federal backstop support for the Terrorism Risk Insurance Act of 2002 (TRIA)/Terrorism Risk Insurance Reauthorization and Extension Act of 2007 (TRIPRA), which has the potential to shift the global landscape towards a tighter market.]
"What we want is for building designers to ask, 'What are the greatest threats to this structure and what can be done about them…?'"

-Dennis Miyoshi, Director of the Security Systems and Technology Center at Sandia National Laboratories

Conflicts sometimes arise between security site design and conventional site design. For example, open circulation and common spaces, which are desirable for conventional 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.

3.1 STANDOFF DISTANCE

Distance is the most effective and desirable antiterrorism design tool because other measures vary in effectiveness, are more costly, and often have unintended consequences. For example, a blast wall can become the source of fragmentation if an explosion occurs in close proximity to it. The most cost-effective solution for mitigating explosive effects is simply to ensure that any explosions occur as far away from the buildings as possible. Adequate standoff distance, illustrated by the following figure, also increases the probability of stopping a weapon-laden vehicle more quickly and makes manned penetration more difficult.
3.1.1 Minimum Standoff Distances

The minimum standoff distances recommended by the Department of Defense (DOD) can be applied to buildings in the private sector with equally good results. These minimum standoff distances are presented in the following two figures:

Fig. 3-1 Minimum DOD Standoff Distances for Facilities with a Controlled Perimeter
Fig. 3-2  Minimum DOD Standoff Distances for Facilities without a Controlled Perimeter

Where the minimum recommended standoff distances can be met, conventional construction may be used for the buildings without a specific analysis of blast effects. Where those distances are not available, the building must be analyzed and building hardening applied as necessary to mitigate the effects of explosives at the achievable standoff distance to the appropriate level of protection.

Standoff distances for parking and roadways in Fig. 3-1 are based on the assumption that there is a controlled perimeter at which larger vehicle bombs will be detected and kept from entering the controlled perimeter. If there is no controlled perimeter, assume that larger explosive weights can access parking and roadways near buildings. Therefore, where there is no controlled perimeter, use the standoff distances shown in Fig. 3-2.

In both cases, the standoff distance is measured from the closest edge of parking areas and roadways to the closest point on the building exterior or inhabited portion of the building. For trash containers, the standoff distance is measured from the nearest point of the trash container or trash container enclosure to the closest point on the building exterior or inhabited portion of the building. Where the standoff distance is not available, harden trash enclosures to mitigate the direct blast effects and secondary fragment effects of the explosive on the building if the applicable level of protection can be proven by analysis. If authorized personnel secure trash enclosures to preclude introduction of objects into the enclosures, they may be located closer to the building as long as they do not violate unobstructed space provisions. Openings in screening materials and gaps between the ground and screens or walls making up an enclosure must not be greater than six inches.
3.1.2 Building Separation

Building separation is required to minimize the possibility that an attack on one building causes injuries or fatalities in adjacent buildings. The separation distance is predicated on the potential use of indirect fire weapons. Activities with large visitor populations provide opportunities for potential aggressors to get near buildings with minimal controls, and therefore, limit opportunities for early detection. Maximize separation distance between inhabited buildings and areas with large visitor populations.

Ensure that adjacent inhabited buildings are separated by at least the distances shown in the figures above. Where it is necessary to encroach on those building separations, analyze the structure and provide hardened building components as necessary to mitigate the effects of explosives.

3.1.3 Unobstructed Space

It is assumed that aggressors will not attempt to place explosive devices in areas near buildings where these explosive devices could be visually detected by building occupants observing the area around the building. Therefore, ensure that obstructions within 30-35 feet of inhabited buildings or portions thereof do not allow for concealment from observation of explosive devices six inches or greater in height. This does not preclude the placement of site furnishings or plantings around buildings; it only requires conditions such that any explosive devices placed in that space would be observable by building occupants.

The preferred location of electrical and mechanical equipment such as transformers, air-cooled condensers, and packaged chillers is outside the unobstructed space or on the roof. However this standard does not preclude placement within the unobstructed space as long the equipment provides no opportunity for concealment of explosive devices.

If walls or other screening devices with more than two sides are placed around electrical or mechanical equipment within the unobstructed space, enclose the equipment on all four sides and the top. Openings in screening materials and gaps between the ground and screens or walls making up an enclosure should not be greater than six inches. Secure any surfaces of the enclosures that can be opened so that unauthorized personnel cannot gain access through them.

3.1.4 Drive-Up/Drop-Off Areas

Some facilities require vehicle access to areas within the required standoff distance for dropping off or picking up people or loading or unloading packages and other objects. Examples that may require drive-up/drop-off include, but are not limited to, medical facilities, exchanges and commissaries, childcare centers, and schools. Locate these points away from large glazed areas of the building to minimize the potential for hazardous flying glass fragments in the event of an explosion. For example, locate the lane at an outside corner of the building or otherwise away from the main entrance. Coordinate the drive-up/drop-off point with the building geometry to minimize the possibility that explosive blast forces could be increased due to being trapped or otherwise concentrated. Do not allow drive-through lanes or drive-up/drop-off to be located under any inhabited portion of a building.

Where operational or safety considerations require drive-up or drop-off areas or drive-through lanes near buildings, ensure those areas or lanes are clearly defined and marked and that their
intended use is clear to prevent parking of vehicles in those areas. Do not allow unattended vehicles in drive-up or drop-off areas or drive-through lanes.

### 3.2 PERIMETER CONTROL

#### 3.2.1 Layout and Form

The overall layout of a 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.

**Building placement.** Depending on the site characteristics, the occupancy requirements, and other factors, buildings may be clustered tightly in one area (*consolidated*), or dispersed across the site (*separated*), as illustrated by the following figure.

Both patterns have strengths and weaknesses.

Concentrating people, property, and operations in one place creates a target-rich environment, and the mere proximity of any one building to any other may increase the risk of collateral impacts. Additionally, the potential exists for the establishment of more single-point vulnerabilities in a clustered design than would exist in a more dispersed pattern. However, grouping high-risk activities, concentrations of personnel, and critical functions into a cluster can help maximize standoff 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 facilities. In addition, combining multiple uses also provides economic and environmental benefits such as opportunities to efficiently transfer heat from net heat-producing areas and activities to net heat-consuming ones, thus reducing energy costs.

In contrast, the dispersal of buildings, people, and operations across the site 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, economics, and other factors allow, the designer should consolidate buildings that are functionally compatible and have similar threat levels. For example, visitor...
screening areas, receiving/loading areas, and mailrooms constitute the innermost line of defense because they may be the first places where people and materials are closely inspected before being introduced into the facility. Logically, they should be physically separated from the key assets such as main operational areas and concentrations of people (see Chapter 4 for further discussion). It is also desirable to locate potential target buildings away from lower-risk areas in order to minimize collateral damage should an attack occur.

**Building orientation.** The orientation of a building can have significant impact on its performance, not only in terms of energy efficiency, but also in the ability to protect occupants. The term “orientation” refers to three distinct characteristics: the building’s spatial relationship to the site, its orientation relative to the sun, and its vertical or horizontal aspect relative to the ground.

A structure’s orientation relative to its surroundings defines its relationship to that area. In aesthetic terms, a 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 subtle, but it 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. Designers should consider such trade-offs early in the design process in an effort to determine an acceptable level of risk.

Daylighting relies inherently on the use of glazing, which has been shown to be one of the major hazards in blast events. In addition to ensuring the maximum setback possible for highly-fenestrated facades, designers should ensure that aperture sizes, glazing materials, films, and frames and connections are selected with blast-resistance as well as energy efficiency in mind.

**Open space.** The incorporation of open space into 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 standoff value of open space, since 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 accesses 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.

### 3.2.2 Vehicular and Pedestrian Circulation

The movement of people and materials into, through, and out of a 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 site’s transportation requirements based on an analysis of how the facility will be used. This includes studying the number and types of access points that are required, the parking volume needed, pedestrian patterns, and the modes of transportation they will use. Several aspects of transportation planning can impact security and are discussed below.

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 buildings. Given that the energy transferred when one object strikes another is a function of its mass and its velocity, a bollard that can stop a 15,000-pound truck moving at 35 miles per hour may not be able to stop the same truck moving at 55 miles per hour. In developing a system of street alignments with protection in mind, the designer cannot determine the size or weight of a vehicle that will travel along the road because that is a management decision. However, the designer can propose a roadway system to minimize vehicle velocity, thus using the roadway itself as a protective measure.

Straight-line or perpendicular approaches to buildings should not be used 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 tight-radius 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 that 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, bollards, 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 enroute 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. Finally, the distinction between speed humps, speed tables, and speed bumps is critical. Speed "humps" and "tables" are much gentler than speed bumps and can be constructed to “enforce” a specific speed range, while speed bumps have much more abrupt profiles and are only appropriate for low-speed applications, such as parking lots.

There are three primary types of parking facilities, all of which present security trade-offs. Surface lots can be designed to keep vehicles away from buildings, but they 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. In contrast, on-street parking is often convenient for users and a source of revenue for local governments, but this type of parking may provide little or no standoff distance. Finally, garage structures provide revenue and can be convenient for users, but they may require structural measures to ensure blast resistance as well as crime prevention measures to prevent street crime. Although the cost of land suggests that the construction of a garage below a building (either underground or aboveground) may be the most economically viable approach for many developments, they can be highly vulnerable to vehicle-borne weapons, endangering the building above. If garages must be used, access and egress control, human security procedures (e.g., driver identification and vehicle searches), and electronic systems (e.g., closed circuit television) may be necessary to ensure safety (see Section 3.6 for additional information on parking).
3.2.3 Critical Infrastructure

Providing power, gas, water, wastewater, and communications services is one of the most basic requirements of any development. All critical utilities, often called "lifelines," should have at least one layer of redundancy or backup. By eliminating single-point vulnerabilities, designers reduce the chance that service will be interrupted if an attack damages or destroys a lifeline either outside the perimeter or onsite. It is important to note that co-locating 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. Designers should be aware that this could create the need for each type of infrastructure lifeline to cross the site perimeter at multiple locations, potentially complicating the process of managing utility easements and rights-of-way.

Additionally, all controls, interconnections, exposed lines, and other vulnerable elements of 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.

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 building. Their destruction could cause damage that is disproportionate to other building damage resulting from an explosion.

To minimize the possibility of hazards to utility systems, apply the following measures:

1. Where possible, provide underground, concealed, and protected utilities.

2. Provide redundant or "looped" utility systems to support site security, life safety, and rescue functions.

3. Consider quick connects for portable utility backup systems if redundant sources are not available.

4. Prepare vulnerability assessments for all utility services to the site, including all utility lines, storm sewers, gas transmission lines, electricity transmission lines, and other utilities that may cross the site perimeter.

5. Protect water treatment plants and storage tanks from waterborne contaminants by securing access points, such as manholes. Maintain routine water testing to help detect waterborne contaminants.

6. Minimize signs identifying critical utility complexes (e.g., power plants and water treatment plants). Provide fencing to prevent unauthorized access and use landscape planting to conceal aboveground systems.
7. Locate petroleum, oil, and lubricant storage tanks and operations buildings downslope from all other buildings. Site fuel tanks at an elevation lower than operational buildings or utility plants. Locate fuel storage tanks at least 100 feet from buildings and away from loading docks, entrances, and parking. Access should be restricted and protected (e.g., locks on caps and seals).

8. Provide utility systems with redundant or looped 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 or consider “quick connects” at the building for portable backup systems.

9. Decentralize a site’s communications resources when possible; the use of multiple communications networks will strengthen the communications system’s ability to withstand the effects of a terrorist attack. Careful consideration should be made in locating, concealing, and protecting key network resources such as network control centers.

10. Consider incorporating low impact development practices to enhance security, such as retaining stormwater onsite in a pond to create standoff distance instead of sending into the site drainage system.

11. Route critical or fragile utilities within the building so that they are not on exterior walls or on walls shared with mailrooms.

12. Where emergency backup systems are required, ensure they are located away from the systems components for which they provide backup.

All utility penetrations at a site’s perimeter barrier, including penetrations in fences, walls, or other perimeter structures, should be sealed or secured to eliminate openings large enough to pass through the barrier. Typical penetrations could be for storm sewers, water, electricity, or other site utility services. Specific requirements of various openings are discussed below:

1. All utility penetrations of the site’s perimeter should be screened, sealed, or secured to prevent their use as access points for unauthorized entry into the site. If access is required for maintenance of utilities, secure all penetrations with screening, grating, latticework, or other similar devices so that openings do not allow intruder access. Provide intrusion detection sensors and consider overt or covert visual surveillance systems if warranted by the sensitivity of assets requiring protection.

2. Drainage ditches, culverts, vents, ducts, and other openings that pass through a perimeter barriers and have a cross-sectional area greater than 96 square inches with the smallest dimension greater than six inches should be protected by securely fastened welded bar grilles. As an alternative, drainage structures may be constructed of multiple pipes, with each pipe having a diameter of ten inches or less. Multiple pipes of this diameter may also be placed and secured in the inflow end of a drainage culvert to prevent intrusion into the area. Ensure that any addition of grilles or pipes to culverts or other drainage structures is coordinated with the engineers so that they can compensate for the diminished flow capacity and additional maintenance that will result from the installation.

3. Manhole covers ten inches or more in diameter must be secured to prevent
Unauthorized opening. They may be secured with locks and hasps, by welding them shut, or by bolting them to their frame. Ensure that hasps, locks, and bolts are made of materials that resist corrosion. Keyed bolts (which make removal by unauthorized personnel more difficult) are also available. If very high security is required, manhole covers that resist shattering after being artificially “frozen” by an aggressor should be considered.

3.2.4 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 should include an emphasis on mixed-use development; 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.

The implications of security for landscape design affect everything from plant species and building material selection to landform construction and wayfinding. 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 and 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 practitioners should consider the unique requirements of the project to ensure that the landscape design elements they choose will be appropriate and effective.

For example, thorn-bearing and sharp-leafed plant species (e.g., firethorn, Spanish bayonet, and pampas grass) can create natural physical barriers to deter aggressors. Although this technique can be highly effective, designers should consider the liability they may incur from injuries resulting from legitimate users inadvertently coming into contact with them. Additionally, although such plants can provide security for ground-level windows, they may also impede emergency egress.

With careful selection, placement, and maintenance, landscape elements can provide visual screening that protects sensitive operations, gathering areas, and other activities from surveillance without creating concealment for covert activity. However, dense vegetation in close proximity to a building can screen illicit activity and should be avoided. Additionally, thick ground cover such as English ivy or vegetation over four 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.

Numerous urban design elements present opportunities to provide 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 day-to-day living, they are also critical for emergency response, evacuation, and egress. Furthermore, despite an emphasis on downsizing the scale of the streetscape, it is critical to maintain the maximum standoff distance possible between vehicles and structures.

At the site 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 move more easily through the space.

Similarly, street furniture (e.g., mailboxes, bus stop shelters, light poles, works of art, street trees, planters, bicycle racks, seating, newspaper boxes, kiosks, and trash receptacles) can be used to enhance security. For example, bus stop shelters can be designed to allow for easy surveillance and detection of suspicious activity and objects. Hardened versions of everyday items, such as light poles, planters, benches, street trees (of appropriate size and type), and even water fountains can serve as vehicle barriers. These items maintain standoff while creating a line-of protection that is virtually transparent and highly permeable at the pedestrian scale. Note that in-ground installation of bollards, fences, and any other anti-ram measures should be preceded by an assessment of soil conditions and underground utilities in the immediate vicinity.

The main challenge for the design community is to reach the desired level of protection without turning the building or facility into a bunker or fortress. In other words, they are required to incorporate subtle and aesthetically pleasing security measures when involved in urban design projects. Below are some rules of thumb that should be taken into consideration when designing an urban landscape with a security component:

1. Security measures must not impede access to public entrances or pedestrian flow on adjacent sidewalks.

2. Landscape elements in the form of grassed plinths, trees, plantings, fountains and pools are appropriate, but must be designed as integral parts of a building and its setting as much as possible.

3. Miscellaneous decorative elements such as flag poles, fountains, pools, gardens, and similar features may be located within an accessway to slow movement or restrict access.

4. Trees planted along the inside edge of a public sidewalk and adjacent to pedestrian and vehicular accessways can serve dual aesthetic and barrier purposes.

5. The design of bollards, fences, light posts, and other streetscape and landscape elements should form an urban ensemble that helps to create a sense of unity and character.

6. Security devices must be designed and located to establish consistent, rhythmic patterns along the street, particularly where a number of elements are used in combination to reduce visual street clutter.
7. Security devices must not obstruct pedestrian movement or access by emergency vehicles; therefore, the use of bollards, posts, and chains may be inappropriate when this function is required.

Landscape and urban design inherently define the “line of sight” in a space. Operational security is not a traditional element of master planning, but managing the threat of hostile surveillance is a significant consideration in protecting people, property, and operations. 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 standoff weapons. In addition to the use of various screening options, anti-surveillance measures (e.g., building orientation, landscaping, screening, and landforms) can also be used to block sight lines.

3.3 CONTROLLED ACCESS ZONES

3.3.1 Physical Protective Barriers

A physical barrier is a means of establishing a controlled access area around a building or site. Physical barriers can be used to define the physical limits of a building or campus and can help to restrict, channel, or impede access and constitute a continuous obstacle around the site. Physical barriers can create a psychological deterrent for anyone planning an unauthorized entry and they can delay or prevent passage into a site. This is especially true of barriers against forced entry by vehicles. The type of barriers utilized can have a direct impact on the number and type of security posts that may be needed to ensure site security. Utility areas (such as water sources, transformer banks, commercial power and fuel connections, heating and power plants, or air conditioning units) may require these barriers for safety standards.

A number of elements may be used to create a physical barrier, some natural and some manmade. Natural barrier elements include rivers, lakes, waterways, steep terrain, mountains, barren areas, plants, and other terrain features that are difficult to traverse. Manmade elements include fencing, walls, bollards, planters, concrete barriers, and fountains. The selection of elements must consider the level of security desired and the type of threat most likely to occur.
Fencing is a common means of establishing a physical barrier to protect a controlled area. The type of fencing used depends primarily on the threat and the degree of permanence. It may also depend on the availability of materials and the time needed for construction. Fencing may be erected for other uses besides impeding personnel access, such as obstructing views, serving as a means to defeat standoff weapon systems (e.g., rocket propelled grenades), and serving as a barrier to hand-thrown weapons (e.g., grenades and firebombs).

*It is important to recognize that fencing provides very little delay when it comes to motivated aggressors, but it can act as a psychological deterrent when an aggressor is deciding which building to attack.* The following are commonly used fencing types:

**Chain-link.** Generally, chain-link fencing is used for protecting permanent limited and exclusion areas. Chain-link fence (including gates) is typically six to ten feet high fence fabric, mounted on steel poles with a top guard or outrigger. Chain-link fences are usually nine-gauge or heavier galvanized wire with mesh openings not larger than two inches per side and have twisted and barbed wire (or barbed tape) at the top and the bottom.

**Anti-climb fence.** Although different styles of anti-climb fences are available, most consist of vertical bars with horizontal supports designed to make climbing difficult.

**Barbed wire.** Standard barbed wire is twisted, double-strand wire, with four-point barbs spaced an equal distance apart along the strand. Barbed wire fencing (including gates) intended to prevent human trespassing should not be less than six feet high and must be affixed firmly to posts not more than six feet apart. Barbed wire may be used as a top guard or outrigger on a standard chain-link fence.

**Barbed tape (razor wire) or concertina.** Barbed taped is fabricated from 0.025-inch stainless steel tape with barbed clusters. Barbed tape can be deployed tangle-free for fast installation without supporting fence posts.

**Triple-standard concertina wire.** This type of fence uses three rolls of stacked concertina; one roll is stacked on top of two other rolls that run parallel to each other while resting on the ground, forming a pyramid. This fence has been used effectively in lieu of a chain-link fence.

**Tangle-foot wire.** Tangle-foot wire is an obstruction fence constructed of barbed wire or tape set up outside a single perimeter fence or in the area between double fences to provide an additional deterrent to intruders. Wire or tape is supported on short metal or wooden pickets spaced at irregular intervals of three to ten feet and at heights between six and twelve inches. The wire or tape should be criss-crossed to provide a more effective obstacle. The space and materials available govern the depth of the field. Liability issues should be considered when installing a tangle-foot wire.

**Cable.** Cable or wire rope can be used as a separate, temporary barrier or it may be attached to chain-link or anti-climb fences to provide additional crash resistance.

A top guard should be installed on all perimeter fences (and may be added to interior enclosures for additional protection). A top guard is an overhang of barbed wire or tape along
the top of a fence, facing outward and upward at approximately a 45-degree angle. Placing barbed wire or tape above it can further enhance the top guard. Top guard supporting arms are permanently affixed to the top of fence posts and increase the overall height of the fence. Three strands of barbed wire spaced six inches apart must be installed on the supporting arms. (Due to liability issues in some locations, the top guards may not be allowed to face outward where the fence is adjacent to public areas.)

Clear zones should be maintained on both sides of the perimeter barrier to provide an unobstructed view of the barrier and the ground adjacent to it. A clear zone of 20 feet or more should exist between the perimeter barrier and exterior structures, parking areas, and natural or manmade features. When possible, a clear zone of 50 feet or more should exist between the perimeter barrier and structures within the protected area, except when the wall of a building constitutes part of the perimeter barrier. Roads within the clear zone should be as close to the perimeter barrier as possible without interfering with it. The roads should be constructed to allow effective road barriers to deter motor movement of unauthorized personnel. When barriers enclose a large area, a perimeter road should be provided for security patrol vehicles on the interior.

Fences may be augmented with additional security systems, such as motion sensors and closed circuit camera systems.

Because barriers can be compromised through breaching (cutting a hole through a fence) or by nature (berms eroded by the wind and rain), they should be inspected and maintained at least weekly. Security inspections should address signs of deliberate breaches, holes in and under barriers, natural debris building up against barriers, and the proper functioning of locks.

### 3.3.2 Other Perimeter Barriers

The exterior of a building may, under some circumstances, form a part of a perimeter barrier. Reinforced brick and block masonry or cast in place concrete walls may act as part of a perimeter barrier. They must be at least seven feet high and must have a barbed wire or barbed tape top guard. The windows, active doors, and other designated openings should be protected with fastening bars, grilles, or chain-link screens, and window barriers should be fastened from the inside. If hinged, the hinges and locks must be on the inside to facilitate emergency egress.

Barrier walls designed to resist the effects of an explosion can, in some cases, act to reduce the pressure levels acting on the exterior walls of buildings. They may not, however, enhance security because they prohibit observation of activities occurring on the other side of the wall. In this case, a plinth wall (anti-ram knee wall) with a fence may be an effective solution to combine antiram capability and observation.

Consideration should also be given to the improvement of a defensive posture should threat levels increase. A number of temporary or semi-permanent measures may be effective. Expedient methods include blocking access routes with heavy vehicles or temporarily blocking roads surrounding a building to create a form of a controlled access area.

Typically street closures exclude vehicles but allow access by pedestrians with proper credentials. The use of street closures must be balanced against minimum circulation/access
requirements and fire protection considerations.

If a secured area requires a limited exclusion area on a temporary or infrequent basis, it may not be possible to use physical structural barriers. A limited exclusion area may be established with additional security posts, patrols, and other security measures during the period of restriction. Temporary barriers (including temporary fences, jersey barriers, and vehicles) may also be used.

3.3.3 Anti-ram Vehicle Barriers

Vehicle barriers are considered either passive or stationary barriers (e.g., fixed bollards, concrete walls, planters, berms, etc.) or active barriers, which can typically be retracted or moved out of the way to allow passage (such as retractable bollards, crash beams, and rotating plates). Passive barriers are used to create perimeter protection; active barriers are applicable to roadways, driveways, or entry control points where they can be lowered or raised to prevent or allow passage.

Passive barriers typically consist of bollards, which are concrete filled steel pipes that can be placed every few feet along the curb of a sidewalk to prevent vehicle intrusion as shown in the following figure. In order to resist the impact of a vehicle, the bollard needs to be fully embedded into a concrete strip foundation that is several feet deep. The height of the bollard above ground should be higher than the bumper of the vehicle, typically 36 to 40 inches. The spacing of the bollards is based on several factors, including Americans with Disabilities Act (ADA) requirements, the minimum width of a vehicle, and the number of bollards required to withstand the impact. As a rule of thumb, the center-to-center spacing should be between three and five feet to be effective.

An alternative to a bollard is a plinth wall, which is a continuous low wall constructed of reinforced concrete with a buried foundation. The bollard or plinth wall is designed by equating the kinetic energy of the vehicle at impact with the strain energy absorbed by the barrier and the vehicle.
The foundation of the bollard and plinth wall system can present challenges. For effectiveness, the barriers need to be placed as close to the curb as possible. The property line of some buildings often does not extend to the curb and, therefore, a permit may be required by the local authorities to place barriers with foundations near the curb. To avoid this, building owners are often inclined to place bollards along the property line, which significantly reduces the effectiveness of the barrier system because it reduces the standoff distance. Sometimes a basement may exist below the pavement that extends to the property line. Embedding a barrier foundation into the basement foundation wall or through the basement roof may introduce water infiltration issues and structural foundation design complications.

The effectiveness of a barrier is based on the amount of energy it can absorb versus the amount of kinetic energy, $KE$, imparted by a head-on vehicle impact:

$$KE = \frac{1}{2} Mv^2$$

where $M$ is the mass of the vehicle and $v$ is the velocity at the time of impact with the barrier. The angle of approach reduces this energy in non-head-on situations and the energy absorbed by the crushing of the bumper also reduces the energy imparted to the barriers. Because the velocity is squared in this equation, a change in velocity affects the result more than a change in vehicle weight. For this reason, it is important to review lines of approach to ensure that a vehicle does not have a long, straight road to pick up speed before impact.

The vehicle weight used for the design of barriers typically ranges from 4,000 pounds for cars up to 40,000 pounds for trucks. Impact velocities range from 30 mph for slanted impact areas (i.e., where the oncoming street is parallel to the curb) up to 70 mph where there is straight-on access (i.e., where the oncoming street is perpendicular to the curb).

In high security sites and at points where access must be provided through an anti-ram perimeter, active or operational anti-ram systems are required. Off-the-shelf products are available that are rated to resist various levels of car and truck impacts. Solutions include crash beams, crash gates, surface mounted plate systems, retractable bollards, and rotating wedge systems.

The following figure shows a very high security shallow foundation movable barricade. This hydraulic barricade system consists of a wedge barrier ramp operated by a hydraulic power unit via hydraulic cylinders. Single or multiple barricades may be operated by a single hydraulic power unit to yield pass through rates of three to fifteen seconds per inspection and identification station specifications. Crash testing shows this type of system to be fully operational after successfully stopping a vehicle weighing 15,000 pounds at 50 mph.
The following are some security considerations for sites requiring a movable vehicle barrier:

1. If the limited availability of land precludes the creation of an exclusive zone, the use of screening surrounding the building is an alternative.

2. 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.). Consider using landscape materials to create barriers that are soft and natural rather than manmade.

3. Vehicles can be used as temporary physical barriers if they are placed in front of buildings or across access roads.

4. Maintain as much standoff distance as possible between vehicles and the 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;
   - When possible, position gates and perimeter boundary fences outside the blast vulnerability envelope; and
   - If the threat level warrants, provide a vehicle crash resistance system in the form of a low wall or earth berm.

3.4 ENTRY CONTROL AND VEHICULAR ACCESS

If perimeter control is employed, it will be necessary to provide at least one point of access through the perimeter for building users (i.e., employees, visitors, and service providers). An entry control point or guard building serves well as the designated point of entry for site access.
It provides a point for implementation of desired levels of screening and access control.

The objective of the entry control point is to prevent unauthorized access while maximizing the rate of authorized access by foot or vehicle.

Design for vehicular access and entry control for a building starts with an evaluation of the anticipated demand for access to the controlled site. An analysis of traffic origin and destination and an analysis of the capability of the surrounding connecting road network, including its capacity to handle additional traffic, should then be performed. Expansion capacity should also be considered. The analysis should be coordinated with the state and local departments of transportation.

The existing terrain can have a significant impact on the suitability of a potential entry control point site. Flat terrain with no thick vegetation is generally preferred. A gentle rise in elevation up to the entry control guard building allows for a clear view of arriving vehicles. Consider how existing natural features such as bodies of water or dense tree stands may enhance perimeter security and vehicle containment. Entry control spatial requirements vary depending on the type, the traffic demand, and the necessary security measures.
In commercial buildings or campuses, more than one type of entry may be required to accommodate the three basic types of traffic, site personnel, visitors, and commercial traffic. Active perimeter entrances should be designated so that security personnel can maintain full control without creating unnecessary delays in traffic. This could be accomplished with a sufficient number of entrances to accommodate the peak flow of pedestrian and vehicular traffic and adequate lighting for rapid and efficient inspection. Some entrances may be closed during non-peak periods and should be securely locked, barricaded against vehicle entry, illuminated during hours of darkness, and monitored. Additionally, warning signs should be used to warn drivers when gates are closed.

The following measures should be considered in the design of entry control points:

1. Minimize the number of access roads and entrances into a building or site.
2. Design entry roads to sites and to individual buildings so that they do not provide direct or straight-line vehicular access to high-risk buildings; route major corridors away from concentrations of high-risk buildings.
3. Design access points at an angle to oncoming streets so that it is difficult for a vehicle to gain enough speed to break through the stations.
4. Designate separate entry to the site for commercial, service, and delivery vehicles, preferably away from high-risk buildings.
5. 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 during periods of peak volume.
6. Approach to the site should be designed to accommodate peak traffic demand without impeding traffic flow in the surrounding road network.
7. Design active vehicle crash barriers as may be required to control vehicle speed and slow incoming vehicles to give entry control personnel adequate time to respond to unauthorized activities.
8. Provide pullover lanes at site entry gates to check suspect vehicles. When necessary, provide a visitor/site personnel inspection area to check vehicles prior to allowing access to a site or building. Design the inspection area so that it is not visible to the public, when necessary. Place appropriate landscape plantings to accomplish screening. Consider current and future inspection technologies (e.g., above vehicle and under vehicle surveillance systems, ion scanning, and x-ray equipment). Provide inspection bays that can be enclosed to protect inspection equipment in the event of bad weather. Design inspection areas that are large enough to accommodate a minimum of one vehicle and a pullout lane. They should also be covered and capable of accommodating the inspection of the undercarriage plus overhead inspection equipment.
10. If possible, provide a gatehouse for the workstations and communications equipment.
of the security personnel. It may also serve as a refuge in the event of an attack. Provide some measure of protection against hostile activity if ID checking is required between the traffic lanes.

11. For high security buildings, provide a final denial barrier to stop unauthorized vehicles from entering the site. Most individuals who may attempt to enter without authorization are lost, confused, or inattentive, but there are also those whose intent may be to “run the gate.” A properly designed final denial barrier will take into account both groups, safely stopping the individuals who have made an honest mistake, but providing a properly designed barrier to stop those with hostile intentions. Design the barrier system to impede both inbound and outbound vehicles. The system should include traffic control features to deter inbound vehicles from using outbound lanes for unauthorized access. Barrier devices that traverse both roadways should be included in the design. The safety features discussed above for inbound lanes should also be provided in the outbound lanes.

Entry-control stations should be provided at main perimeter entrances where security personnel are present. In addition, entry-control stations should be located close to the perimeter entrance to permit people inside the station to maintain constant surveillance over the entrance and its approaches. Additional considerations at entry-control stations include:

1. Entry-control stations that are manned 24 hours each day, should have interior and exterior lighting, interior heating and cooling (where appropriate), and a sufficient glassed area to afford adequate observation for people inside. Where appropriate, entry-control stations should be designed for optimum personnel ID and movement control. Each station should include a telephone, a radio, and badge racks (if required).

2. Signs should be erected to assist in controlling authorized entry, to deter unauthorized entry, and to preclude accidental entry. Signs should be plainly displayed and legible from any approach to the perimeter from a reasonable distance. The size and coloring of a sign, its letters, and the interval of posting must be appropriate to each situation.

3. Entry-control stations should be hardened against attacks according to the type of threat. The methods of hardening may include:

- Reinforced concrete or masonry;
- Steel plating;
- Ballistic glass; and
- Commercially fabricated, bullet-resistant building components or assemblies.

3.5 SIGNAGE

Wayfinding is an important function of design that illustrates the importance of coordination among practitioners and community planning, public works, transportation, law enforcement, and fire-rescue organizations. The ability of users to navigate an unfamiliar environment is important for its success on a day-to-day basis, but will become critical in an emergency
situation. In addition to overt prompts such as landmarks, architectural elements, consistent signage and maps, users will subconsciously relay on cues from their surroundings to help them select a path to safety. Similarly, emergency responders will depend in part on these design elements in order to navigate the scene.

Signs are an important element of security. They are meant to keep intruders out of restricted areas; however, inadequate signs can create confusion and defeat their primary purpose. Confusion over site circulation, parking, and entrance locations can contribute to a loss of site security. Signs should be provided off site and at entrances. There should be on-site directional, parking, and cautionary signs for visitors, employees, service vehicles, and pedestrians. Unless required, signs should not identify sensitive areas. A comprehensive signage plan should include the following:

1. Prepare signs for each entry control building.

2. Prepare entry control procedures signs, which explain current entry procedures for drivers and pedestrians.

3. Prepare traffic regulatory and directional signs that control traffic flow and direct vehicles to specific appropriate points.

4. Consider using street addresses or building numbers instead of detailed descriptive information inside the site.

5. Minimize the number of signs identifying high-risk buildings; however, a significant number of warning signs should be erected to ensure that possible intruders are aware of entry into restricted areas.

6. Minimize signs identifying critical utility complexes (e.g., power plants and water treatment plants). Post clear signs to minimize accidental entry by unauthorized personnel into critical asset areas.

7. Install warning signs that are easy to understand along the physical barriers and at each entry point.

8. Warning signs must use both (or more) languages in areas where two or more languages are commonly spoken (both English and Spanish in North Carolina). The wording on the signs should denote warning of a restricted area. 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. Additionally the warning signs should be posted at all entrances to limited, controlled, and exclusion areas.

9. Locate variable message signs that give information on site/organization special events and visitors far inside site perimeters.

3.6 PARKING

Parking restrictions can help to keep potential threats away from a 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. Operational measures may also be necessary to inspect or screen vehicles entering parking garages. The following considerations may help designers to implement sound parking measures for buildings that may be at high risk:

1. Locate vehicle parking and service areas away from high-risk buildings to minimize blast effects from potential vehicle bombs (see Section 3.2).

2. Restrict parking from the interior of a group of buildings.

3. If possible, locate visitor or general public parking near, but not on, the site itself.

4. If possible, design the parking with one-way circulation to facilitate monitoring for potential aggressors.

5. Locate parking within view of occupied buildings.

6. When establishing parking areas, provide emergency communication systems (e.g., intercom, telephones, etc.) at readily identified, well-lit, closed circuit television monitored locations to permit direct contact with security personnel.

7. Provide parking lots with closed circuit television cameras connected to the security system and adequate lighting capable of displaying and videotaping lot activity.

8. 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 building on the site to provide adequate setback from adjacent properties.

9. Prohibit parking beneath or within a building. If parking beneath a building is unavoidable, limit access to the parking areas and ensure they are secure, well lit, and free of places of concealment. If parking within the building is required, the following restrictions may be applied:
   • Public parking with ID check;
   • Company vehicles and employees of the building only; or
   • Selected company employees only, or those requiring security.

10. Apply the following when parking inside a building is necessary and the building superstructure is supported by the parking structure:
   • Protect primary vertical load carrying members by implementing architectural or structural features that provide a minimum six-inch standoff from the face of the member; and
   • Design columns in the garage area for an “unbraced length” equal to two floors, or three floors where there are two levels of parking.

11. For all standalone, aboveground parking garages, maximize visibility for surveillance
into, out of, and across the garage.

12. Employ express or non-parking ramps, sending the user to parking on flat surfaces.

13. Avoid dead-end parking areas, as well as nooks and crannies.

Additional parking considerations include:

1. Stairways and elevator lobby design should be as open as code permits. The ideal solution is a stair and/or elevator waiting area totally open to the exterior and/or the parking areas. Designs that ensure that people using these areas can be easily seen (and can see out) should be encouraged. If a stair must be enclosed for code or weather protection purposes, glass walls can be used to deter potential attacks. Potential hiding places below stairs and within and around stairwells should be closed off.

2. Elevator cabs should have glass backs whenever possible. Elevator lobbies should be well lighted and visible to both patrons in the parking areas and the people outside the building.

3. Pedestrian paths should be designed to concentrate activity to the extent possible. For example, bringing all pedestrians through one portal rather than allowing them to disperse to numerous access points improves the ability to see and be seen by other users. Limiting vehicular entry/exits to a minimum number of locations is also beneficial.

3.7 LOADING DOCKS AND SERVICE ACCESS

Loading docks and service access areas are commonly required for a 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 undesirable intruders. Design criteria for loading docks and service access include the following:

1. 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.

2. 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 a blast. The loading dock design should limit damage to adjacent areas and vent explosive forces to the exterior of the building.

3. If loading zones or drive-through areas are necessary, monitor them and restrict height to keep out large vehicles.

4. Avoid having driveways within or under buildings.

5. 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 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.

6. Provide signage to clearly mark separate entrances for deliveries.

3.8 SITE PLANNING AND DESIGN CHECKLIST

The following checklist can be used as a summary of this chapter and a design guide:

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))? Do future development plans change these land uses outside the facility (site or building(s)) perimeter?

Although these questions bridge 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 one mile upwind for the prevailing winds versus ten 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.

Critical infrastructure to consider includes:

- Telecommunications infrastructure such as 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, including 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.

- Banking and finance institutions such as financial institutions (banks, credit unions) and the business district; note schedule business/financial district may follow; armored car services.

- Transportation networks that include 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 plants.
• Government services: Federal/state/local government offices, post offices, law enforcement stations, fire/rescue, town/city hall, local mayors/governors residences, judicial offices and courts, military installations.
• Emergency services: Backup facilities, communications centers, Emergency Operations Centers (EOC's), fire/Emergency Medical Service (EMS) facilities, Emergency Medical Center (EMC's), law enforcement facilities.

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 EPA 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.

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.

3. **In 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 close to the curb lane. Setback is common terminology for the distance between a building and its associated roadway or parking. It is analogous to standoff between a vehicle bomb and the building. The benefit per foot of increased standoff 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.

4. **Is a perimeter fence or other types of barrier controls in place? If not, can perimeter control be incorporated into the design?**

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.

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; traffic can be routed through the other access point.

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.

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 onsite parking with identification checks, security personnel, and access control systems.
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.

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, and stormwater runoff culverts, etc. Ensure covers to these access points are secured.

10. What are the existing or potential new 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.

11. What is the anti-ram buffer zone standoff distance from the building to unscreened vehicles or parking?

If the recommended distance for the postulated threat is not available, consider reducing the standoff required through structural hardening or manufacturing additional standoff through barriers and parking restrictions. Also, consider relocation of vulnerable functions within the building or to a more hazard-resistant building. More standoff should be used for unscreened vehicles than for screened vehicles that have been searched.

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?

Adequately designed bollards, street furniture, sculpture, landscaping, walls, and fences may provide anti-ram protection. 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 (serpentesines or speed bumps) to limit the speed at impact. If the resultant speed is still too great, the anti-ram protection should be improved.

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.

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.
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 standoff.

16. **Does adjacent surface parking on site maintain a minimum standoff distance?**

The specific standoff distance needed is based upon the design basis bomb threat 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.

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.

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.

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.

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.
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.

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.

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.

24. **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, e.g., flushing toilets, building heating and cooling system operation, cooling of emergency generators, humidification, etc.

25. **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.

26. **Is the incoming water supply in a secure location?**

Ensure that only authorized personnel have access to the water supply and its components.

27. **Does the building or site have storage capacity for domestic water? How many gallons of storage capacity are available and how long will it allow operations to continue?**

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.

28. **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.

29. 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.

30. 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.

31. Are there redundant fire pumps (e.g., one electric, one diesel)? Are the pumps located apart from each other?

Collocating fire pumps puts them at risk for a single incident to disable the fire suppression system.

32. 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.

33. What fuel supplies does the building rely upon for critical operation?

Typically, natural gas, propane, or fuel oil is required for continued operation.

34. 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).

35. Where is the fuel supply obtained? How is it delivered?

The supply of fuel is dependent on the reliability of the supplier.

36. 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.

37. 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.

38. **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.

39. **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 (*North Carolina Electric Code*) are met for multiple service entrances.

40. **Is the incoming electric service to the building secure?**

Typically, the service entrance is a locked room, inaccessible to the public.

41. **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.

42. **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.

43. **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.

44. **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.

45. **Are utility lifelines aboveground, underground, or direct buried?**
Utility lifelines (water, power, communications, etc.) should be protected by concealing, burying, and/or encasing. Redundant or looped systems should be provided.
DESIGNING FOR TERRORISM: ARCHITECTURE

If the standoff distances defined in Chapter 3 cannot be maintained, then the building and its envelope must be designed to reduce the potential of damage to the building and injury or death to its occupants due to external explosion. A second goal for the architect is to utilize space planning to isolate higher risk areas such as mailrooms, lobbies, service areas, etc. from the core of the building to minimize the impact of an internal explosion.

4.1 BUILDING CONFIGURATION

As with the discussion of clustered versus dispersed buildings in Chapter 3, designers should balance a number of relevant considerations to the extent that site, economic, and other factors allow. Some of the relevant considerations include the following:

**Low, Large-footprint Buildings:**

1. Distribute people, assets, and operations across a wider area, to limit damage;

2. Use vegetation, terrain, and other screening elements to protect from hostile surveillance (see Chapter 3);

3. Maximize the benefits of green roof technologies, which can help reduce a building’s heat signature and lower its visual profile; and

4. Require the use of additional measures to prevent introduction of CBR agents due to easier access to HVAC intakes by intruders.

**Tall, Small-footprint Buildings:**

1. Tall, small-footprint buildings suffer damage to a greater percentage of their façades, structures, and interiors at best, and catastrophic damage or collapse at worst, should a large blast occur near the building if not constructed with progressive collapse prevention in mind;

2. Elevate occupied areas above vegetation, terrain, and other screening elements,
making it potentially more difficult to protect interior spaces from outside surveillance;

3. Minimize the amount of impervious surface, contributing to a reduction in stormwater runoff, which reduces the need for culverts, drainage pipes, manholes, and other covert site access and weapon concealment opportunities; and

4. Provide greater opportunity to elevate HVAC intakes to prevent the introduction of CBR agents.

The shape of the building can also 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. In general, convex rather than concave shapes are preferred for the exterior of the building. For example, circular buildings act to reduce the air-blast pressures because the angle of incidence of the shock wave increases more rapidly than in a rectangular building.

The following design considerations are recommended:

1. Reduce a building’s vulnerability to blast by using earth-sheltered design;

2. Orient buildings horizontally rather than vertically to reduce the building’s profile and exposure;

3. Place the ground floor elevation of a building at four feet above grade to prevent vehicle ramming;
4. 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;

5. Orient glazing perpendicular to the primary facade to reduce exposure to blast and projectiles;

6. Avoid exposed structural elements (e.g., columns) on the exterior of the facility; and

7. Provide pitched roofs to allow deflection of launched explosives.

4.2 SPACE DESIGN

Unsecured areas should be physically separated from the main building to the extent possible. For example, a separate lobby pavilion or loading dock outside the main footprint provides enhanced protection against damages and potential building collapse in the event of an explosion. Similarly, placing parking areas outside the main footprint of the building can be highly effective in reducing the vulnerability to catastrophic collapse.

The protection of the building interior can be divided into two categories: functional layout and structural layout. In terms of functional layout, public areas such as the lobby, loading dock, mailroom, garage, and retail areas need to be separated from the more secured areas of the facility. This can be done by creating internal “hard lines” or buffer zones using secondary stairwells, elevator shafts, corridors, and storage areas between public and secured areas.

In lobby areas, consider the queuing requirements in front of the inspection stations so that visitors are not forced to stand outside during bad weather conditions or in a congested line inside a small lobby while waiting to enter the secured areas. Emergency functions (e.g., sprinkler systems and generators, which are critical for mitigating the effects of an explosion) and elevator shafts should be placed away from internal parking areas and loading docks. In the 1993 World Trade Center bombing incident, elevator shafts became chimneys, transmitting smoke and heat from the explosion in the basement to all levels of the building. This hindered evacuation and caused smoke inhalation injuries. When it is not possible to separate mechanical areas and parking, the walls need to be designed to resist explosive forces.

When designing high-risk buildings, consider the following:

**Safe havens:** The innermost layer of protection within a physical security system is the safe haven. Safe havens are not intended to withstand a disciplined, paramilitary attack featuring explosives and heavy weapons. The safe haven should be designed such that the time attackers need to penetrate the protected area is greater than the time that first responders need to reach the protected area.

Safe havens can also serve as areas of refuge to protect building occupants that cannot leave a building during an outdoor CBR release or are trapped within the building due to damage and fire resulting from an explosion. Safe haven areas (and exit stairways in multi-story buildings) should be designed as *smokeproof enclosures* in accordance with Section 909.20 of the 2002 North Carolina Building Code.
Office locations: Offices considered to be high risk (more likely to be targeted by terrorists) should be placed or glazed so that the occupants cannot be seen from an uncontrolled public area such as a street. Whenever possible, these spaces should face courtyards, internal sites, or controlled areas. If this is not possible, suitable obscuring glazing or window treatment should be provided, including ballistic-resistant glass, blast curtains, or other interior protection systems.

Mixed occupancies: High-risk tenants should not be housed with low-risk tenants. Terrorists may identify some targets based on their symbology, visibility, ideology, political views, potential for publicity, or simply the consequences of their loss.

Public toilets and service areas: Public toilets, service spaces, or access to vertical circulation systems should not be located in any non-secure areas, including the queuing area before visitor screening at the public entrance.

Retail uses in the lobby: Retail and other mixed uses, which have been encouraged in public buildings by the Public Buildings Cooperative Use Act of 1976, create spaces that are open and inviting. Although important to the public nature of the buildings, the presence of retail and other mixed uses may present a risk to buildings and their occupants and should be carefully considered on a project-specific basis during project design. In areas exposed to potential terrorist attacks, retail and mixed uses may be accommodated through such means as separating entryways, controlling access, and hardening shared partitions, as well as with special security operational countermeasures.

Stairwells: Stairwells required for emergency egress should be located as remotely as possible from areas where blast events might occur and, wherever possible, should not discharge into lobbies, parking, or loading areas.

Mailroom: The mailroom (or any area used to receive, sort, or store deliveries from the outside) should be located away from facility main entrances areas containing critical services, utilities, distribution systems, and important assets. In addition, the mailroom should be located at the perimeter of the building with an outside wall or window designed for pressure relief. It should have adequate space for explosive disposal containers. An area near the loading dock is a preferred mailroom location. Where these rooms are located in occupied areas or adjacent to critical utilities, walls, ceilings, and floors, they should be blast- and fragment-resistant. Significant structural damage to the walls, ceilings, and floors of the mailroom is acceptable; however, the areas adjacent to the mailroom should not experience severe damage or collapse.

Miscellaneous: Other elements that should be considered include:

1. Locating critical assets in spaces that are occupied 24 hours per day;
2. Locating assets in areas visible to more than one person;
3. Eliminating hiding places within the building;
4. Using interior barriers to differentiate levels of security with in a building;
5. Staggering doors located across from one another in interior hallways to limit the effects of a blast through a structure;
6. Providing entry foyers with reinforced concrete walls and offset interior and exterior doors; and

7. Implementing methods to facilitate the venting of explosive forces and gases from the interior spaces to the outside of the structure. Examples of such methods include the use of 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.

4.3 BUILDING ENVELOPE

At the building exterior, the focus shifts from deterring and delaying the attack to mitigating the effects of an explosion. The exterior envelope of the building is the most vulnerable to an exterior explosive threat because it is the part of the building closest to the weapon.

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 consist of 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.

Soil can be highly effective in reducing the impact of a major explosive attack. Bermed walls and buried rooftops have been found to be highly effective for military applications and can be effectively extended to conventional construction. This type of solution can also be effective in improving the energy efficiency of the building. Note that if this approach is taken, no parking should be permitted on top of the building.

4.3.1 Exterior Wall Design

The exterior walls provide the first line of defense to prevent blast pressures and hazardous debris from entering the building. They would be subject to direct reflected pressures from an explosive threat located directly across from the wall along the secured perimeter line. If the building is more than four stories high, it may be advantageous to consider the reduction in pressure with height due to the increased distance and angle of incidence. At a minimum, the objective of design is to ensure that these members fail in a flexible mode rather than a brittle mode such as shear. The walls also need to be able to resist the loads transmitted by the windows and doors. It is not uncommon for bullet-resistant windows to have a higher ultimate capacity than the walls to which they are attached. 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 doorframes.

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

For pre-cast panels, consider a minimum thickness of five inches with two-way, reinforcing bars spaced not greater than the thickness of the panel. Connections into the structure should provide a straight line of load transmittal using as few connecting pieces as possible.
For CMU block walls, use eight-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 continuous exterior CMU wall that laterally bears against the floor system is a preferred 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 must be designed to resist the ultimate lateral capacity load of the system.

For the design of exterior walls, consider the following:

1. Exterior walls should resist the actual pressures and impulses acting on the exterior wall surfaces from the threats defined for the facility. Special consideration should be given to construction types that reduce the potential for collapse where exterior walls are not designed for the full design loads. By U.S. military standards, a "medium" protection level for walls would be the equivalent of four-inch concrete with #5 reinforcing steel at six-inch intervals each way or eight-inch CMU with #4 reinforcing steel at eight-inch intervals.

2. Exterior walls should be capable of withstanding the dynamic reactions from the windows.

3. 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. Design exterior shear walls to resist the actual blast loads predicted from the threats specified.

Cladding and finishes design should be based on the following:

1. Substitute strengthened building elements and systems when standoff distances cannot be accommodated;

2. Use ductile materials capable of very large plastic deformations without complete failure;

3. Provide blast-resistant walls when a high threat is present;

4. Consider use of sacrificial exterior wall panels to absorb blast;

5. Use earthtone colored materials and finishes on exterior surfaces to diminish the prominence of a building (think "Cary, North Carolina");

6. Consider reinforced concrete wall systems in lieu of masonry or curtain walls to minimize flying debris in a blast; and

7. 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.

In addition to mitigating the potential damage from a bomb blast, the exterior wall has a second function relative to CBR threats (see Chapter 6). To minimize the entry of external release CBR
agents into an occupied building, it is important that all areas of a building be maintained under a positive pressure at all times. A key to this requirement is the design of an effective air barrier as part of the wall construction.

The air barrier's function is to stop outside air from entering or infiltrating the building through the wall and inside air from exfiltrating. To do this, the air barrier must seal the openings in the building envelope and be strong enough to withstand the physical buffeting of the air pressures acting on it. Installation quality of the air barrier is critical to its successful performance. While the effectiveness of a vapor retarder diminishes linearly as the number of penetrations increases, the effectiveness of an air barrier diminishes exponentially as the number of joints, cracks, and crevices increases. Thus, the performance of an air barrier depends on its being as penetration-free as possible.

Three primary effects contribute to the total air pressure acting on an air barrier. The first is stack effect, also known as "chimney effect", which results from the thermal buoyancy of air due to changes in density with temperature in buildings three or more stories in height. During winter, the warm air inside a building rises and exits near the top. This, in turn, draws in cooler air at the bottom of the building. This effect produces an outward pressure over the top half of the building and a suction force at the bottom. During summer, air conditioning causes the pressures and flow directions to be reversed.

The second driving mechanism is wind pressure. Airflow around and over a building creates a positive pressure on the windward side driving infiltration. Suction pressures cause exfiltration on the leeward side. The pressure differences vary rapidly with time due to turbulence and changes in wind direction. Since wind speeds increase with height, wind-driven pressure differences across the building envelope also increase with height.

The third source of air pressure differences comes from mechanical exhaust and/or ventilation provided by fans. These produce pressure differences that are distributed rather uniformly over the envelope area. Being a sustained load, even small fan pressures can have a significant effect upon the air barrier by forcing some materials out at joints or to come apart at seams.

An air barrier system must meet four (4) requirements. These are continuity, air impermeability, strength and durability.

**Continuity** requires that the air barrier of a wall must be continuous with the air barrier system of the roof and windows. *The same materials throughout need not achieve this continuity, but each material involved in the control of air leakage must be connected to the others into a continuous plane of air tightness.* For example, the air barrier of the roof at the perimeter must connect to the air barrier of the exterior wall, as shown in the following figure:
Air Impermeability means the air barrier materials and system must be virtually airtight. Typically, an air barrier system should not leak in excess of 0.02 CFM/sf at 0.30" wg air pressure difference. To achieve this level of performance, a designer must choose materials with air permeability ratings of less than this value.

Canada Mortgage and Housing Corporation undertook several studies to develop a test method and to obtain the air permeability of various construction materials. Forty to fifty typical construction materials were conditioned at a standard temperature and humidity. The amount of air leakage that resulted was converted into air permeability ratings, as summarized in the following table, where "Rate" is tabulated in terms of CFM/sf at 0.30" wg and where "NML" indicates "No Measurable Leakage":

<table>
<thead>
<tr>
<th>Material</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth surfaced roofing, 2 mm</td>
<td>NML</td>
</tr>
<tr>
<td>Modified torch-on membrane (glass mat)</td>
<td>NML</td>
</tr>
<tr>
<td>Modified torch-on membrane (polyester Matt)</td>
<td>NML</td>
</tr>
<tr>
<td>Modified peel and stick membrane, 1.3 mm</td>
<td>NML</td>
</tr>
<tr>
<td>Polyethylene film, (6 mil)</td>
<td>NML</td>
</tr>
<tr>
<td>Aluminum foil</td>
<td>NML</td>
</tr>
<tr>
<td>Plywood sheathing, 3/8 in.</td>
<td>NML</td>
</tr>
<tr>
<td>Foil backed gypsum board</td>
<td>NML</td>
</tr>
<tr>
<td>Extruded polystyrene insulation, 1 in.</td>
<td>NML</td>
</tr>
<tr>
<td>Foil backed urethane insulation,</td>
<td>NML</td>
</tr>
<tr>
<td>Cement board, 1/2 in.</td>
<td>NML</td>
</tr>
<tr>
<td>Gypsum board, (FB), 1/2 in.</td>
<td>NML</td>
</tr>
<tr>
<td>THERMOLITE Insulation</td>
<td>0.00071</td>
</tr>
</tbody>
</table>
TYVEK HomeWrap      0.00077
Plywood sheathing, 1/4”     0.00132
Gypsum board, (MR), 1/2”     0.00179
ISOCLAD insulation     0.00224
Spunbonded olefin film     0.00256
Particle board, 1/2”      0.00305
Gypsum wallboard, 1/2”     0.00386
TYVEK CommercialWrap     0.00098
Expanded polystyrene insulation, type II  0.02337
Roofing felt, 30 lb.        0.03687
Non-perforated asphalt felt, 15 lb.   0.05327
Expanded polystyrene insulation, type I   2.409
Tongue and groove planks     3.763
Glass-fiber insulation      7.231

**Note**: Ratings for board materials are based on taped butt joints, both horizontal and vertical. Tape must be metallic foil type with air leakage rating of NML.

**Strength** means the air barrier system must be attached to a supporting structure and it must resist excessive deflection, cracking, rupture, or pull through at fasteners. The air barrier system must withstand the highest expected air pressure load, usually wind, inward or outward, without detaching from its support. It must also resist peak wind loads, a sustained stack effect or a sustained pressurization load without exhibiting creep load failure (gradual unbonding of a membrane from its support).

**Durability** requires that an air barrier system and its components be designed and constructed to perform their intended function for the life of the building, and more particularly, the life of the building envelope. It must be made of strong and robust materials with adequate resistance to various environmental loads. Alternately, it must be positioned in the building envelope so that it may be serviced as required or maintained at a reasonable cost.

Polyethylene film is not suitable as an air barrier material as it is too fragile; continuity is difficult to achieve at penetrations and joints; and, most importantly, there is inadequate structural support of the membrane against wind pressure deformations.

*In the hot, humid climates of North Carolina and the rest of the South, the air barrier should be located outboard of the vapor barrier, immediately inboard of the rain barrier.* An intact and functioning air barrier prevents the vapor retarder from having to resist pressure loads. Since the pressure field around the building is constantly changing, the air barrier must be designed to withstand both positive and suction pressures at all points. Methods of attachment to the building require close scrutiny to insure that they are adequate for the job. Likewise, if a flexible material is used it must be properly supported on both sides. If the air barrier or its attachment system is unable to resist the peak air pressure loads, it will be damaged or displaced and thus rendered inoperable.

An air barrier in a wall system, however, should never be viewed as an adequate envelope seal to offset a depressurized interior building space and prevent internally induced infiltration. The building envelope must work with the HVAC system to establish a pressurized building. Because cavities that may exist within a wall system provide potential pathways for outside air,
maintaining proper pressurization is crucial to avoiding infiltration of outside air into these spaces.

The performance of the air barrier is critical and, therefore, commissioning the air barrier system is important. An adequate budget needs to be assigned early in the project process to fund the commissioning activities needed to ensure a successful outcome that meets the owner’s project expectations for a tight building enclosure. The cost of testing a commercial building can vary from $1,000 to $15,000 depending on complexity and size.

Assemblies of opaque walls, curtain walls and windows can be tested in the lab in accordance with NFRC 400 or ASTM E 283 (air infiltration), ASTM E 331 (water penetration under static pressure), AAMA test procedure 501.1 (water penetration under dynamic pressure), ASTM E 330 (structural adequacy), NFRC 500 or AAMA 1502.7 (condensation resistance factor or CRF), NFRC 100 or AAMA 1503.1 (thermal transmittance), NFRC 200 (solar heat gain coefficient), and NFRC 300 (solar optical properties of glazing products).

Another test for air barrier assemblies is ASTM E1677. This is a test for low-rise residential buildings and includes an eight-foot by eight-foot panel that has panel joints, a blanked-off window, a duct penetration, an electric outlet, etc. The maximum test pressure suggested in this test may be too low to simulate wind loads for most building locations and for taller buildings, so a test pressure more representative of design wind and gust pressures at the project site (plus a safety factor) should be required by the designer. Infiltration is reported with this test as cfm/ft² at 0.3 in. w.g. (equivalent to approximately 15 mph wind pressure).

Testing whole commercial buildings is rarely done in the U.S. It is common in Canada and has become a requirement for building acceptance in the U.K. since 2002. Testing standards include:

1. Whole building, floors, or suites, ASTM E 779, Determining Airtightness of a Building’s Air Leakage Rate by Single Zone Air Pressurization;

2. CAN/CGSB 1986 Standard 149.10, Determination of the Airtightness of Building Enclosures by the Fan Depressurization Method; and


Trailer-mounted fans (with large blower doors) for testing large buildings, delivering up to 55,000 cfm at 0.3 in. w.g. or larger, are available from at least one U.S. source. Several of these may be required to test a large, leaky, building, although inaccuracies are introduced with the use of multiple fans. In testing a whole building, all the “intentional holes” such as ventilation air intakes, exhaust fan outlets and louvers, elevator shaft smoke exhaust, flues, etc. have to be sealed, usually with polyethylene and tape. Low wind conditions (lower than 8.5 mph) and only a small temperature differential between indoor and out (outdoor temperature between 40°F and 95°F) helps reduce the influence of wind and stack effects.

Interior doors need to be open so the building is turned into a single zone. The volume of air being moved is recorded at the pressure differential; this is done for several different pressures in steps of 0.05 to 0.3 in. w.g. If the building is too large to test with a single fan, multiple fans can be used, or the building’s air handlers can be used instead; the fans need to be evaluated.
for cfm output; the test can then proceed and the fans progressively turned on to pressurize the building with pressure measurements taken at each step.

### 4.3.2 Window Design

Window systems on the exterior façade of a building should be designed to mitigate the hazardous effects of flying glass during an explosion event. Windows, if possible, should be oriented to face "safe" directions and not be exposed to potential blast hazards, as shown in the following figure:

![Window Design Diagram](image)

Designs should integrate the type of glass, connection of the glass to the frame ("bite"), and anchoring of the frame to the building structure. 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.

The US General Services Administration (GSA) has created a standard test method for evaluating blast resistance and glass hazard mitigation technologies that are subjected to blast loading events.
For this standard, the figure above represents the cross section of a reaction structure, the concrete enclosure in which these technologies are tested for either blast resistance or glass hazard mitigation on a blast testing range. This structure contains a window mounted in a test frame on one wall with a “witness panel” on the opposite wall of the structure. The witness panel is constructed of foam covered with paper to record any fragments of glass that may strike the back wall during the test. The window or the related glass hazard mitigation technology attached to the window can then be tested.

A blast from an explosive charge is set off from a standardized distance to create a pre-defined blast pressure for a pre-determined duration. When the air blast impacts the window, the resulting damage is measured and recorded. The criteria shown in the table below describes the response of the window after the blast. If the window fails and glass is blown into the structure the resulting speed and trajectory of the fragments are recorded by how far away from the frame they fall or how high they may have impacted the witness panel.

If the glass does not shatter and is not affected by the blast, the resulting technology is given a rating of 1. If the glass cracks but does not release from its frame the resulting technology is given a rating of 2. If the glass breaks and is contained within a distance of less than 3.3 feet from the front wall then it is given a rating of 3a. If the glass breaks and is contained within a distance of more than 3.3 feet and less than 10 feet from the front wall and does not impact the witness panel then it is given a rating of 3b. If the glass breaks and the fragments perforate the witness panel (10 feet from the front wall) less than 2 feet from the floor it is given a rating of 4. If the glass breaks and the fragments perforate the witness panel (10 feet from the front wall) above 2 feet from the floor it is given a rating of 5.

The following table summarizes the six GSA glazing protection levels based on how far glass fragments would enter a space and potentially injure its occupants:

<table>
<thead>
<tr>
<th>Performance Condition</th>
<th>Protection Level</th>
<th>Hazard Level</th>
<th>Description of Window Glazing Response to Explosive Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Safe</td>
<td>None</td>
<td>Glazing does not break. No visible damage to glazing or window frame.</td>
</tr>
<tr>
<td>2</td>
<td>Very High</td>
<td>None</td>
<td>Glazing cracks, but is retained by the frame. Dusting or very small fragments near sill or on floor.</td>
</tr>
<tr>
<td>3a</td>
<td>High</td>
<td>Very Low</td>
<td>Glazing cracks. Fragments enter space and land on floor not more than 3-4 feet from window.</td>
</tr>
<tr>
<td>3b</td>
<td>High</td>
<td>Low</td>
<td>Glazing cracks. Fragments enter space and land on floor not more than 10 feet from window.</td>
</tr>
<tr>
<td>4</td>
<td>Medium</td>
<td>Medium</td>
<td>Glazing cracks. Fragments enter space and land on floor and impact vertical witness panel at a distance of not more than 10 feet from the window at a height not greater than 2 feet above the floor.</td>
</tr>
<tr>
<td>Performance Condition</td>
<td>Protection Level</td>
<td>Hazard Level</td>
<td>Description of Window Glazing Response to Explosive Forces</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------</td>
<td>--------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>5</td>
<td>Low</td>
<td>High</td>
<td>Glazing cracks and window system fails catastrophically. Fragments enter space, impacting vertical witness panel at a distance of not more than 10 feet from the window at a height not greater than 2 feet above the floor</td>
</tr>
</tbody>
</table>

The divide between performance conditions 3a and 3b in the table above can be equated to the “threshold of injury.” The divide between performance conditions 4 and 5 can be equated to the “threshold of lethality.” Note that performance conditions 2, 3a, 3b, 4, and 5 allow glazing fragments to be thrown outside of the protected space toward the detonation location.

Four types of glass are commonly used in window glazing systems: annealed glass, heat-strengthened glass, fully thermally tempered glass, and polycarbonate, as follows:

**Annealed glass**, also known as float, plate, or sheet glass, is the most common glass type used in commercial construction. Annealed glass is of relatively low strength and upon failure, fractures into razor sharp, dagger-shaped fragments.

**Fully thermally tempered glass** (TTG) is typically four to five times stronger than annealed glass with a design stress of 16,000 psi. The fracture characteristics of tempered glass are superior to those of annealed glass. Upon failure, it will eventually fracture into small cube-shaped fragments. Breakage patterns of side and rear windows in American automobiles are a good example of the failure mode of thermally tempered glass. Current building codes generally require thermally tempered glass anywhere the public can physically touch the glass such as entrance doors and sidelights. Although thermally tempered glass exhibits a relatively safe failure mode for conventional usage, failure under blast loading still presents a significant health hazard. Results from blast tests reveal that, upon fracture, TTG fragments may be propelled into cohesive clumps that only fragment upon impact into similar rock salt-type fragments. Even if the tempered glass breaks up initially into small fragments, the blast overpressure can propel the fragments at a high enough velocity to constitute a severe hazard.

**Wire-reinforced glass** is a common glazing material consisting of annealed glass with an embedded layer of wire mesh. Its primary use is as a fire-resistant and forced entry barrier. Wire-reinforced glass has the fracture and low strength characteristics of annealed glass and, although the wire binds some fragments, it still ejects a considerable amount of sharp glass and metal fragments. Wire-reinforced glass is not recommended for blast-resistant windows.

**Laminated glass** is a pane with multiple glass layers and a pliable interlayer material, usually made from polyvinyl butyral (PVB) between the glass layers. Combining interlayer bonding materials with layers of glass produces cross-sections that perform well against blast, ballistic, and forced entry attacks. The interlayer acts as the glue that bonds the multiple layers of glass into a single pane of a given thickness and provides a membrane response after the glass layers crack under loading.
Laminated glass offers significant advantages over monolithic glass. It is stronger and, if failure occurs, the interlayer material retains most of the glass fragments. Also, if a projectile passes through the glass, most spalling glass fragments will be retained. Increased safety for fragment retention can be obtained in the event of catastrophic failure from an explosive blast by placing a decorative crossbar or grillwork on the interior of the glazing. Note: crossbars must be mounted across the center of mass of each windowpane to be effective.

The following photos illustrate the impact and blast resistance of laminated glass:

Another treatment used for mitigating the effects of an explosive attack is security window film. This polyester film is commonly referred to as fragment retention film (FRF), safety film, security film, protective film, or shatter-resistant film. These films are adhered to the interior surface of the window to provide fragment retention and reduce the overall velocity of the glass fragments at failure. Fragment retention film combines a strong pressure sensitive adhesive with a tough
polyester layer. Four methods are used to attach security film to windows: a daylight attachment (applied only to the vision opening); edge-to-edge attachment (applied out to the edge of the glass); wet-glazed attachment (daylight or edge-to-edge film with a silicone bead along edge of the frame); and a mechanical attachment. Because fragment retention film applies directly to the glass surface of a windowpane, it is beneficial for retrofitting existing windows as well as on new windows, provided the frame "bite" is sufficient.

Fragment retention film behaves similarly to relatively thin laminated and polycarbonate glazing in terms of fragmentation. It is available in common thickness of 2, 4, 7, and 10 millimeters. Fragment retention film improves the performance of the glass under blast loading to varying degrees depending on the thickness, quality, and type of film installation. The best performance is achieved when the film is installed into the bite of the glazing or is connected to the frame. Fragment retention film can also provide solar control benefits. As with laminates, increased safety can be obtained with window films by placing a decorative crossbar or grillwork on the interior of the glazing.

Thermoplastic polycarbonates are very strong and suitable for blast- and forced entry-resistant window design. Monolithic polycarbonate is available in thickness up to ½ inch, but can be fused together to obtain any thickness needed. However, polycarbonate is expensive and subject to environmental degradation (especially from exposure to aromatic hydrocarbons) and abrasion. Local building codes should be consulted when considering polycarbonates. There are several fire safety issues associated with its use (thermoplastic polycarbonate is rated as a class GG-1 material and will often test with a smoke density rating over 500). Additionally, because of its strength, local fire codes may require a percentage of polycarbonate glazing to pop out for emergency egress.

Window frames need to retain the glass so that the entire pane does not fall out and should be designed to resist the breaking stress of the window glass. To retain the glass in the frame, a minimum of a ¼-inch bead of structural sealant (i.e., silicone or polyvinyl butyral) should be used around the inner perimeter of the window. The allowable tensile strength should be at least 20 psi. Also, the window bite (i.e., the depth of window captured by the frame) needs to be at least ½ inch. In some applications (e.g., the lobby area where large panes of glass are used), a larger bite with more structural sealant may be needed. Frame and anchorage design is performed by applying the breaking strength of the window to the frame and the fasteners. In most conventionally designed buildings, the frames are aluminum; however, in some applications, steel frames are used.

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, increasing both 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 linear 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 time window glass), the ultimate resistance force of the mullion, the peak pressure, and the equivalent linear decay time be known.
Peak lateral response of the mullion is to be limited to a two-degree support rotation. Also, the displacement ductility is to be limited to a four-degree support rotation. As with frames, it is good engineering practice to limit the number of interlocking parts used for the mullion.

A similar approach may be used for checking time response of the supporting wall response. It makes no sense to have blast mitigating windows if they are stronger than the wall that they are anchored into. The maximum strength of any window and anchorage system should be equal to the wall strength. This becomes particularly important in the design of ballistic-resistant and forced-entry mitigating windows, which consist of one or more inches of glass and polycarbonate. These windows can easily become stronger than the supporting wall. In some applications, even the use of tempered glass can become problematic.

Window systems design (glazing, frames, anchorage to supporting walls, etc.) on the exterior facade should be balanced to mitigate the hazardous effects of flying debris in an explosive event. The walls, anchorage, and window framing should fully develop the capacity of the glazing material selected. The designer may use a combination of methods such as government produced and sponsored computer programs (e.g., Window Lite Analysis Code (WINLAC), Safety Viewport Analysis Code (SAFEVU), Blast-Resistant Window Program (BLASTOP), and Window Glazing Analysis Response and Design (WINGARD)) coupled with test data and recognized dynamic structural analysis techniques to show that the glazing either survives the specified threats or the post damage performance of the glazing protects the occupants.

In general, laminated glass is the preferred glazing material for new construction. Tests have shown that laminated glass performs well under blast loads if mounted in properly designed window frames and can be engineered to offer the highest levels of protection from glass fragments.

Keep in mind that the pressures exerted on a building in a large explosion (e.g., a truck bomb) are often significantly greater than the pressures for which protected windows are designed. For these large events, the upgraded solutions during renovation may not be effective except for windows on the sides of the building not facing the explosion or adjacent buildings. This is particularly true if structural damage occurs. Flying debris generated by structural damage typically causes more severe injuries than window damage alone; however, blast-mitigating window designs are expected to be effective for a large number of threats where the pressures are low. Two such scenarios include a package bomb near the building or a truck bomb that goes off a block away.

Although these solutions do provide protection at modest pressure levels, they are not a “magic shield.” The threat of attack still exists and injuries may still follow if an attack occurs. These measures will be most effective if considered as a “last resort” measure used in conjunction with a full range of physical and operational security measures at the facility.

General guidelines for windows and glazing include the following:

1. Do not place windows adjacent to doors because if the windows are broken, the doors can be locked.

2. Minimize the number and size of windows in a facade. If possible, limit the amount of glazed area in building facades to 15 percent or less. The amount of blast entering a space is directly proportional to the amount of openings on the facade.

4. Consider rising laminated glass in place of conventional glass.

5. Consider window safety laminate (such as Mylar) or another fragment retention film over glazing (properly installed) to reduce fragmentation.

6. Consider placing guards, such as grilles, screens, or meshwork, across window openings to protect against covert entry. Affix protective window guards firmly to the structure.

7. Consider installing blast curtains, blast shades, or spall shields to prevent glass fragments from flying into the occupied space.

8. Consider curtains, blinds, and shades to limit entry of incendiary devices.

9. Consider narrow recessed windows with sloped sills because they are less vulnerable than conventional windows.

10. Consider windows with key-operated locks because they provide a greater level of protection than windows with simple latches. Stationary, non-operating windows are preferred for security.

11. Position the operable section of a sliding window to the inside of the fixed section and secure it with a locking metal rod or bar placed at the bottom of the track.

12. Provide horizontal windows six feet above the finished floor to limit entry.

13. Harden the windows by using steel window frames securely fastened or cement grouted to the surrounding structure.

Additional glazing requirements include the following:

1. Ballistic windows, if required, should meet the requirements of Underwriters Laboratory (UL) 752 Bullet-Resistant Glazing for a level appropriate for the project. Glassclad polycarbonate or laminated polycarbonate are two types of acceptable glazing material.

2. Security glazing, if required, should meet the requirements of the American Society for Testing and Materials (ASTM) Fl 233 or UL 972, Burglary-Resistant Glazing Material.

3. Glazing should meet the minimum performance specified in Table 3-2; however, special consideration should be given to frames and anchorages for ballistic-resistant windows and security glazing because their inherent resistance to blast may impart large reaction.

4. Resistance of window assemblies to forced entry (excluding glazing) should meet the requirements of ASTM F 588 for a grade appropriate for the project.

5. Interior glazing should be minimized where a threat exists. The designer should
avoid locating critical functions next to high-risk areas with glazing, such as lobbies, loading docks, etc.

Under normal operating conditions, windows function in a variety of ways, including allowing light into a building, conserving energy by reducing thermal transmission and/or solar cooling loads, and reducing noise through acoustic transmission.

Explosions are one of a number of abnormal loading conditions that the building may be designed to mitigate. Some of the others are fire, earthquake, hurricane, gunfire, and forced-entry. In developing a protection strategy for windows to mitigate the effects of a particular explosion threat scenario, it is important to consider how this protection may interfere with some of these functions or other explosion threat scenarios. Some suggestions that may be worthwhile to consider are:

1. If an internal explosion occurs, will the upgraded windows increase smoke inhalation injuries by preventing the smoke from venting through windows that would normally break in an explosion event?

2. If a fire occurs, will it be more difficult to break protected windows in order to vent the building and gain access to the injured?

3. Will a window upgrade that is intended to protect the occupants worsen the hazards to passersby?

4.3.3 Doors

A door system includes the door, frame, and anchorage within the wall. As part of a balanced 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.

Because doors are less attack-resistant than adjacent walls because of functional requirements, construction, and method of attachment, other general door considerations are as follows:

1. Keep exterior doors to a minimum while accommodating emergency egress.

2. Limit normal entry/egress through one door, if possible.

3. Provide hollow steel doors or steel-clad doors with steel frames.

4. Provide blast-resistant doors for high threats and high levels of protection.

5. Ensure that exterior doors open outward from inhabited areas. In addition to facilitating egress, the doors can be seated into the doorframes so that they will not enter the building as hazardous debris in an explosion.

6. Replace externally mounted locks and hasps with internally locking devices because the weakest part of a door system is time latching component.

7. Install doors, where practical, so that they present a blank, flush surface to the outside to reduce their vulnerability to attack. Locate hinges on the interior or provide concealed hinges to reduce their vulnerability to tampering.
8. Install emergency exit doors so that they facilitate only exiting movement.

9. Equip any outward-opening double door with protective hinges and key-operated mortise-type locks.

10. Provide solid doors or walls as a backup for glass doors in foyers.

11. Strengthen and harden the upright surfaces of doorjambs.

### 4.4 FIRE RESISTANCE

Progressive collapse of the building structure can be initiated by an explosion and is mitigated by designing the structure to prevent it from occurring (see Chapter 5). However, progressive collapse can also be initiated by a general weakening of the structure, or portions thereof, by fire.

To protect the building, especially steel frames, from collapse, the *North Carolina Building Code* requires that the structure be "protected." This passive protection can be via providing fire barriers (floor-ceiling or roof-ceiling assemblies), encasement with fire resistive materials, and/or by spray-on fireproofing material.

A detailed evaluation of the World Trade Center (WTC) collapse by the National Institute of Standards and Technology (NIST) found that even though the steel structure of this building was protected in accordance with codes similar to North Carolina’s, the structural failure and collapse of the building originated from fire weakening the steel frame in the building. The fire resistant materials used to protect the steel failed for two reasons:

1. Much of the spray-on fireproofing material was damaged or dislodged by impact and explosion; and

2. The fire "loading," the amount of fire fuel and temperature attained, were both much higher than would occur with a normal building fire and, thus, the amount of fire protection was simply inadequate.

While it can (and is) argued that airplanes crashing into buildings is not a reasonable design criteria for architects and structural engineers to meet, there is clear evidence that explosives and/or firebombs can produce similar effects on a building. *Thus, NIST recommends that the fire resistance rating on structural members be increased to 4 hours, rather than the more typical building code requirements of 1-2 hours.* This increased level of fire protection will help compensate for potential damage to the fireproofing by explosion and the potential increased fire fuel loading imposed by firebombs (ranging from Molotov cocktails to 8,000-gallon tanker trucks).

*Concrete structural members have an inherent fire resistance rating and are, therefore, the preferred structural material for buildings to resist terrorist attack.* With a minimum dimension of 14 inches, concrete columns provide the required four-hour fire rating. Concrete beams and floor slabs can also easily achieve a four-hour fire rating by providing adequate concrete cover over the internal steel reinforcing (typically 2-2.5 inches).
Steel may not burn, but it will soften and weaken when subjected to intense heat, requiring the need for fireproofing. (In Chapter 5, the use of fire resistant structural steel is discussed to reduce this weakening under fire conditions by 25-30%.) Thus, all steel frames must still be protected by enclosing the structural member in masonry or GWB materials or by applying spray-on fireproofing materials to yield the required four-hour rating.

1. For unit masonry enclosures, such as brick and CMU, six to eight inches of coverage will provide the required four-hour fire rating. Concrete can also be used for enclosure, typically requiring four to six inches of thickness for column protection.

2. GWB enclosures must be constructed of Type X ("Fire Code") gypsum wallboard in accordance with ASTM C 36. The thickness of GWB required to protect columns and beams can be determined from Chapter 7 the 2006 North Carolina Building Code.

3. Spray-on fireproofing material may be a Portland cement or gypsum-based product and can be applied directly to most structural steel columns, beams, and decking. The thickness of spray-on material to provide the required protection can be determined from Chapter 7 of the 2006 North Carolina Building Code.

4. Finally, there are new "thin-film" intumescent spray-on fireproofing materials that can be applied to steel. These water-based materials can be applied to a thickness of less than 0.7 inch to provide up to three and one half hours fire resistance rating. This material has the advantage of providing an attractive architectural finish and, thus, can be used in exposed locations where traditional spray-on would be unacceptable.

The use of fire-rated floor-ceiling or roof-ceiling assemblies are discouraged. Ceilings are subject to significant damage from explosion and fire, far more damage than would be experienced by hard-cast spray-on fireproofing. Equally important, over time the fire resistance rating of any ceiling is degraded by routine above-ceiling maintenance activities, and the older the building, the greater the degradation. Finally, the effectiveness of HVAC radiation dampers at air outlets and inlets and the "boxing" of light fixtures is highly suspect when subject to blast overpressures.

4.5 ARCHITECTURE CHECKLIST

The following figure and checklist can be used as a summary of this chapter and a design guide:
1. **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.

2. **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.

3. **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.

4. **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.

5. **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, retail and mixed uses create open and inviting buildings. Consider separating entryways, controlling access, hardening shared partitions, and special security operational countermeasures.

6. **Is access control provided through main entrance points for employees and visitors?**

A lobby receptionist, sign-in requirement, staff escorts, issuing visitor badges, checking forms of personal identification, electronic access control systems, etc. are access control measures that should be considered.

7. **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.? Is access to elevators distinguished as to those that are designated only for employees and visitors?**

Finishes and signage should be designed for visual simplicity.

8. **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.

9. **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.

10. **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.

11. **Do circulation routes have unobstructed views of people approaching controlled access points?**

This applies to building entrances and to critical areas within the building.

12. **Is roof access limited to authorized personnel by means of locking mechanisms?**

Roof access points should be locked and monitored.

13. **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; and 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.

14. 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.

15. Is high visitor activity away from critical assets?

High-risk activities should be separated from low-risk activities. Also, visitor activities should be separated from daily activities.

16. 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?

Several persons must monitor critical assets at all times.

17. 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 mains, etc.?

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.

18. 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.
19. **Does the mailroom have adequate space available for equipment to examine incoming packages and for an explosive disposal container?**

Screening of all deliveries to the building, including U.S. mail, commercial package delivery services, delivery of office supplies, etc.

20. **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.

21. **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 *North Carolina Building Code*.

22. **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.

23. **Do interior barriers differentiate levels of security within a building?**

24. **Are emergency systems located away from high-risk areas?**

The intent is to keep the emergency systems out of harms way, such that one incident does not take out all capability, both regular systems and their backups.

25. **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.

26. **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 30 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 requirement does not preclude the need to design equipment mountings for forces required by other criteria, such as seismic standards.
27. What is the designed or estimated protection level of the exterior walls against the postulated explosive threat?

The performance of the facade 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.

28. Is a continuous, well-designed air barrier incorporated into the exterior walls?

The air barrier significantly reduces air infiltration, makes building pressurization easier to maintain, and reduces the potential entrance airborne CBR agents.

29. Is there less than a 15 percent fenestration opening per structural bay? Is the window system design on the exterior facade 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 1/2-inch (3/4-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-millimeters thick film, or specially manufactured 4-millimeter 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 15 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. 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 (fourth floor and higher).

30. 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 facade 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.

31. **Does the building contain ballistic glazing?** 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?

Glass-clad polycarbonate or laminated polycarbonate are two types of acceptable glazing material. If windows are upgraded to be 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.

32. **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.
The primary antiterrorism structural design consideration is maintaining the building's structural integrity during and after an explosion. *If the recommended minimum standoff distances are achieved, conventional construction should minimize the risk of mass casualties from a terrorist attack.* Even if those standoff distances can be achieved, however, the following additional structural issues should be incorporated into a building design to ensure that it does not experience progressive collapse due to blast and/or fire effects.

### 5.1 PROGRESSIVE STRUCTURAL COLLAPSE

#### 5.1.1 Alternative Design Methods

*Progressive collapse* is a situation where local failure of a primary structural component caused by explosion 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.

Current building codes do have design requirements to ensure a minimum level of structural redundancy and durability. They do not, however, have requirements that a building remain intact even with the loss of primary structural elements. The various "levels" of progressive collapse can be illustrated as follows:
Progressive collapse is considered to be significant risk for buildings of three or more stories when subjected to a blast and/or fire incident. Basements will be considered stories if they have one or more exposed walls. For all new and existing inhabited buildings of three stories or more, design the superstructure to sustain local damage with the structural system as a whole remaining stable and not being damaged to an extent disproportionate to the original local damage. Achieve this through an arrangement of the structural elements that provides stability to the entire structural system by transferring loads from any locally damaged region to adjacent regions capable of resisting those loads without collapse. Accomplish this by providing sufficient continuity, redundancy, or energy dissipating capacity (ductility, damping, hardness, etc.), or a combination thereof, in the members and connections of the structure. The measures below apply to all buildings of three or more stories.

ASCE-7 (Reference 9, Section 5.2) defines three ways to approach the structural design of buildings to mitigate damage due to progressive collapse. Each is described below with an emphasis on how the method is applied in the situation where explosive loads are the initiating cause of collapse:

**Indirect Method:** Consider incorporating general structural integrity measures throughout the process of structural system selection, layout of walls and columns, member proportioning, and detailing of connections to enhance overall structural robustness. In lieu of calculations demonstrating the effects of explosions on buildings, designers may use an implicit design approach that incorporates measures to increase the overall robustness of the structure. This minimum standard is likely to be the primary method used for design currently since other
analysis methods have not yet been fully developed and disseminated.

**Alternate-Load-Path Method:** Localize response by designing the structure to carry loads by means of an alternate load path in the event of the loss of a primary load-bearing component. This method provides a formal check of the capability of the structure to resist collapse following the removal of specific elements, such as a building column at the building perimeter. The method does not require characterization of the explosive threat. The structural engineer can usually perform the necessary analyses, with or without guidance from a protective design consultant. However, the analysis is likely to benefit from advice of the protective design consultant regarding element loss scenarios that should be considered in design.

**Specific Local-Resistance Method:** Explicitly design critical vertical load bearing building components to resist the design-level explosive forces. Explosive loads for a defined threat may be explicitly considered in design by using nonlinear dynamic analysis methods. These are discussed below in reference to indirect design methods, with additional information in the subsection on structural elements. Blast-mitigating structural design or hardening generally focuses on the structural members on the lower floor levels that are closest to defined stationary exterior vehicle weapon threats.

### 5.1.2 Building Structural Systems

In the selection of the structural system, consider both the direct effects of blast and the potential for progressive collapse in the event that a critical structural component fails. To resist the direct effects of blast, the structural characteristics listed below are desirable:

**Mass:** Lightweight construction is unsuitable for providing blast resistance. For example, a building with steel deck (without concrete fill) roof construction will have little blast resistance.

**Shear Capacity:** Primary members and/or their connections should ensure that flexural capacity is achieved prior to shear failure. Avoiding brittle shear failure significantly increases the structure's ability to absorb energy.

**Capacity for Reversing Loads:** Primary members and their connections should resist upward pressure. Certain systems such as prestressed concrete may have little resistance to upward forces. Seated connection systems for steel and precast concrete may also have little resistance to uplift. The use of headed studs is recommended for affixing concrete fill over steel deck to beams for uplift resistance.

To reduce the risk of progressive collapse in the event of the loss of structural elements, the structural traits listed below should be incorporated.

**Redundancy:** The incorporation of redundant load paths in the vertical load carrying system helps to ensure that alternate load paths are available in the event of failure of structural elements.

**Ties:** An integrated system of ties in perpendicular directions along the principal lines of structural framing can serve to redistribute loads during catastrophic events.

**Ductility:** In a catastrophic event, members and their connections may have to maintain their strength while undergoing large deformations.
Historically, the preferred material for explosion-mitigating construction is cast-in-place, reinforced concrete. This is the material used for military bunkers, and the military has performed extensive research and testing of its performance. Reinforced concrete has a number of attributes that make it the construction material of choice. It has significant mass, which improves response to explosions because the mass is often mobilized only after the pressure wave is significantly diminished, reducing deformations. Members can be readily proportioned and reinforced for ductile behavior. The construction is unparalleled in its ability to achieve continuity between the members. Finally, concrete columns are less susceptible to global buckling in the event of the loss of a floor system.

Current testing programs are investigating the effectiveness of various conventional building systems; however, in general the level of protection that may be achieved using these materials is lower than what is achieved using well-designed, cast-in-place, reinforced concrete. The performance of a conventional steel frame with concrete fill over metal deck depends on the connection details. 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.

5.1.3 Indirect Design Method

The indirect design approach, as defined by ASCE 7-2005, requires that the "ties" between structural members be such that the loss of a single member will result in the other members absorbing the load, perhaps with significant deformation, but without failure. This requirement is illustrated by the following figure:

To enhance the overall robustness of the structure as an indirect approach to structural design, the measures listed below are recommended:

1. In frame structures, column spacing should be limited and never exceeding 30 feet. Large column spacing decreases likelihood that the structure will be able to redistribute load in event of column failure. The exterior bay on the most exposed side of the building is most vulnerable to damage, particularly for buildings that are close to public streets. It is also less capable of redistributing loads in the event of member loss since
two-way load distribution is not possible. It is desirable to have a shallow bay adjacent to the building exterior to limit the extent of damage.

2. Use of transfer girders is strictly discouraged, since loss of a transfer girder or one of its supports can destabilize a significant area of the building. Transfer girders are often found at the building exterior to accommodate loading docks or generous entries, increasing the vulnerability to blast effects. It is highly desirable to add redundant transfer systems where transfer girders are required.

3. Limit floor-to-floor heights to 16 feet or less.

4. In bearing-wall systems that rely primarily on interior cross-walls or interior longitudinal walls should be periodically spaced to enhance stability and to control the lateral progression of damage.

5. In bearing-wall systems that rely on exterior walls, perpendicular walls or substantial pilasters should be provided at a regular spacing to control the amount of wall that is likely to be affected.

5.1.4 Direct Design Method

The direct design method used for the structural protective measures is to first design the building for conventional loads, then evaluate the structure’s response to explosive loads and augment the design if needed. Finally, the designer must make sure that conventional load requirements are still met. This approach ensures that the design meets all the requirements for gravity and natural hazards in addition to blast effects. (Note that measures taken to mitigate explosive loads may reduce the structure’s performance under other types of loads, and therefore an iterative approach may be needed. As an example, increased mass generally increases the design forces for seismic loads, whereas increased mass generally improves performance under explosive loads. Careful consideration between the protective design consultant and the structural engineer is needed to provide an optimized design.)

Nonlinear dynamic analysis techniques used for direct design are similar to those currently used in advanced seismic analysis. Analytical models range from handbook methods to equivalent single-degree-of-freedom (SDOF) models (see figure below) to finite element (FE) representation. For SDOF and FE methods, numerical computation requires adequate resolution in space and time to account for the high-intensity, short-duration loading and nonlinear response.
A single degree of freedom system consists of a mass, a spring, and a damper if the system is modeled as a damped system, as illustrated by the figure above. The spring is modeled as a linear spring, which provides a restoring force. The damper is modeled as a viscous damper, which provides a damping force proportional to a relative displacement and acting in the direction against a velocity vector. If there is a driving force acting on the mass, the system vibrates under the driving force, which is called forced vibration. Otherwise, the system may vibrate under initial displacement and/or initial velocity, which is called free vibration.

Finite element analysis (FEA) or finite element method (FEM) is a numerical technique for solution of boundary-value problems. It was first developed in the late forties for use in structural analysis. In its application, the object or system is represented by a geometrically similar model consisting of multiple, linked, simplified representations of discrete regions, i.e., finite elements. Equations of equilibrium, in conjunction with applicable physical considerations such as compatibility and constitutive relations, are applied to each element, and a system of simultaneous equations is constructed. The system of equations is solved for unknown values using the techniques of linear algebra or nonlinear numerical schemes, as appropriate. While being an approximate method, the accuracy of the FEA method can be improved by refining the model using more elements and nodes. Numerous computer-based analysis programs are available to designers.

With both SDOF and FEA, difficulties involve the selection of the model and appropriate failure modes and the interpretation of the results for structural design details. Whenever possible, results should be checked against data from tests and experiments for similar structures and loading. Charts are available that provide damage estimates for various types of construction, as a function of peak pressure and peak impulse, based of analysis or empirical data. Military design handbooks typically provide this type of design information.

Components such as beams, slabs, or walls can often be modeled by a SDOF system and the governing equation of motion solved by using numerical methods. There are also charts available in textbooks for linearly decaying loads, which provide the peak response and circumvent the need to solve differential equations. The charts require only knowledge of the fundamental period of the element, its ultimate resistance force, the peak pressure applied to the element, and the equivalent linear decay time to evaluate the peak displacement response of the system. The design of the anchorage and supporting structural system can be evaluated by using the ultimate flexural capacity obtained from the dynamic analysis.

For SDOF systems, material behavior can be modeled using idealized elastic, perfectly plastic
stress-deformation functions, based on actual structural support conditions and strain-rate-enhanced material properties. The model properties selected provide the same peak displacement and fundamental period as the actual structural system in flexure. Furthermore, the mass and the resistance functions are multiplied by mass and load factors, which estimate the actual portion of the mass or load participating in the deflection of the member along its span.

For more complex elements, the engineer must resort to finite-element numerical time integration techniques and/or explosive testing. The time and cost of the analysis cannot be ignored when choosing design procedures. Because the design process is a sequence of iterations, the cost of analysis must be justified in terms of benefits to the project and increased confidence in the reliability of the results. In some cases, an SDOF approach will be used for the preliminary design, and a more sophisticated approach using finite elements, and/or explosive testing may be used for the final verification of the design.

A dynamic nonlinear approach is more likely than a static approach to provide a section that meets the design constraints of the project. Elastic static calculations are likely to give overly conservative design solutions if the peak pressure is considered without the effect of load duration. By using dynamic calculations instead of static, we are able to account for the very short duration of the loading. Because the peak pressure levels are so high, it is important to account for the short duration to properly model the structural response. In addition, the inertial effect included in dynamic computations greatly improves response. This is because by the time the mass is mobilized, the loading is greatly diminished, enhancing response. Furthermore, by accepting that damage occurs it is possible to account for the energy absorbed by ductile systems through plastic deformation. Finally, because the loading is so rapid, it is possible to enhance the material strength to account for strain-rate effects.

In dynamic nonlinear analysis, response is evaluated by comparing the ductility (i.e., the peak displacement divided by the elastic limit displacement) and/or support rotation (the angle between the support and the point of peak deflection) to empirically established maximum values that have been established by the military through explosive testing. Note that these values are typically based on limited testing and are not well defined within the industry at this time. Maximum permissible values vary, depending on the material and the acceptable damage level.

Levels of damage computed by means of analysis may be described by the terms minor, moderate, or major, depending on the peak ductility, support rotation and collateral effects. A brief description of each damage level is given below:

**Minor:** Nonstructural failure of building elements such as windows, doors, cladding, and false ceilings. Injuries may be expected and fatalities are possible but unlikely.

**Moderate:** Structural damage is confined to a localized area and is usually repairable. Structural failure is limited to secondary structural members such as beams, slabs, and non-load-bearing walls. However, if the building has been designed for loss of primary members, localized loss of columns may be accommodated. Injury and possible fatalities are expected.

**Major:** Loss of primary structural components such as columns or transfer girders precipitates loss of additional adjacent members that are adjacent to or above the lost member. In this case, extensive fatalities are expected and the building is usually not
repairable.

Generally, moderate damage at the design threat level is a reasonable design goal for new construction unless the threat level is very high.

The USDOD has issued new structural design guidelines, UFC 4-023-03, 25 January 2005, Unified Facilities Criteria (UFC), *Design Of Buildings To Resist Progressive Collapse*. This UFC employs a “combined approach,” in which indirect design is used for “normal” buildings by specifying minimum levels of strength, ductility, redundancy, and continuity. If the building is “unusual” or the consequences of a progressive collapse event are severe, then explicit consideration of the resistance to progressive collapse must be considered through a direct design approach. This combined approach is thought to add minimal expense while significantly improving the ability of structures to resist progressive collapse. The British employ a similar combined approach in their Building Standards.

However, direct design methods require that the designer anticipate the potential damage to a building from explosion and analyze the required structural system on the basis of that anticipation. Many experts find this less than satisfactory. As terrorists become bolder and use larger and larger explosive weapons, there is no way any designer can accurately predict and design to address all potential attack scenarios. The results from the direct design approach may not exceed, or even meet, the results form the indirect design method, they may simply be less expensive to implement.

### 5.1.5 Structural Elements

Because direct explosion effects decay rapidly with distance, the local response of structural components is the dominant concern. General principles governing the design of critical components are discussed below.

**Exterior Frame:** There are two primary considerations for the exterior frame. The first is to design the exterior columns to resist the direct effects of the specific threats. The second is to ensure that the exterior frame has sufficient structural integrity to accept localized failure without initiating progressive collapse.

Because columns do not have much surface area, blast loads on columns tend to be mitigated by “clear-time effects.” This refers to the pressure wave washing around these slender tall members, and consequently the entire duration of the pressure wave does not act upon them. On the other hand, the critical threat is directly across from them, so they are loaded with the peak reflected pressure, which is typically several times larger than the incident or overpressure wave that propagating through the air.

For columns subjected to a vehicle weapon threat on an adjacent street, buckling and shear are the primary effects to be considered in analysis. If a very large weapon is detonated close to a column, shattering of the concrete due to multiple tensile reflections within the concrete section can destroy its integrity.

Buckling is a concern if lateral support is lost due to the failure of a supporting floor system. This is particularly important for buildings that are close to public streets. In this case, exterior columns should be capable of spanning two or more stories without buckling. Slender steel columns are at substantially greater risk than are concrete columns.
Confinement of concrete using columns with closely spaced closed ties or spiral reinforcing will improve shear capacity, improve the performance of lap splices in the event of loss of concrete cover, and greatly enhance column ductility. The potential benefit from providing closely spaced closed ties in exterior concrete columns is very high relative to the cost of the added reinforcement.

For steel columns, splices should be placed as far above grade level as practical. It is recommended that splices at exterior columns that are not specifically designed to resist blast loads employ complete-penetration welded flanges. Welding details, materials, and procedures should be selected to ensure toughness.

For a package weapon, column breach is a major consideration. Some suggestions for mitigating this concern are listed below:

1. Do not use exposed columns that are fully or partially accessible from the building exterior. Arcade columns should be avoided.

2. Use an architectural covering that is at least six inches from the structural member. This will make it considerably more difficult to place a weapon directly against the structure. Because explosive pressures decay so rapidly, every inch of distance will help to protect the column.

3. Load-bearing, reinforced concrete wall construction can provide a considerable level of protection if adequate reinforcement is provided to achieve ductile behavior. This may be an appropriate solution for the parts of the building that are closest to the secured perimeter line (within twenty feet). Masonry is a much more brittle material that is capable of generating highly hazardous flying debris in the event of an explosion. Its use is generally discouraged for new construction.

4. Spandrel beams of limited depth generally do well when subjected to air blast. In general, edge beams are very strongly encouraged at the perimeter of concrete slab
construction to afford frame action for redistribution of vertical loads and to enhance the shear connection of floor to columns.

**Roof System:** The primary loading on the roof is the downward blast pressure. The exterior bay roof system on the side(s) facing an exterior threat is the most critical. The blast pressure on the interior bays is less intense, so the roof there may require less hardening. Secondary loads include upward pressure due to the air blast penetrating through openings and upward suction during the negative loading phase. The upward pressure may have an increased duration due to multiple reflections of the internal blast wave. It is conservative to consider the downward and upward loads separately.

The preferred system is cast-in-place reinforced concrete with beams in two directions. If this system is used, beams should have continuous top and bottom reinforcement with tension lap splices. Stirrups to develop the bending capacity of the beams closely spaced along the entire span are recommended.

Somewhat lower levels of protection are afforded by conventional steel beam construction with a steel deck and concrete fill slab. The performance of this system can be enhanced by use of normal-weight concrete fill instead of lightweight fill, increasing the gauge of welded wire fabric reinforcement and making the connection between the slab and beams with shear connector studs. Since it is anticipated that the slab capacity will exceed that of the supporting beams, beam end connections should be capable of developing the ultimate flexural capacity of the beams to avoid brittle failure. Beam-to-column connections should be capable of resisting upward as well as downward forces.

Precast and pre- and post-tensioned systems are generally considered less desirable, unless members and connections are capable of resisting upward forces generated by rebound from the direct pressure and/or the suction from the negative pressure phase of the air blast.

Concrete flat slab/plate systems are also less desirable because of the potential of shear failure at the columns. When flat slab/plate system is used, they should include features to enhance their punching shear resistance. Continuous bottom reinforcement should be provided through columns in two directions to retain the slab in the event that punching shear failure occurs. Edge beams should be provided at the building exterior.

Lightweight systems, such as untopped steel deck or wood frame construction, are considered to afford minimal resistance to blast. These systems are prone to failure due to their low capacity for downward and uplift pressures.

**Floor System:** The floor system design should consider three possible scenarios: blast loading, redistributing load in the event of loss of a column or wall support below, and the ability to arrest debris falling from the floor or roof above.

For structures in which the interior is secured against bombs of moderate size by package inspection, the primary concern is the exterior bay framing. For buildings that are separated from a public street only by a sidewalk, the uplift pressures from a vehicle weapon may be significant enough to cause possible failure of the exterior bay floors for several levels above ground. Special concern exists in the case of vertical irregularities in the architectural system, either where the exterior wall is set back from the floor above or where the structure steps back to form terraces.
Structural hardening of floor systems above unsecured areas of the building such as lobbies, loading docks, garages, mailrooms, and retail spaces should be considered. In general, critical or heavily occupied areas should not be placed underneath unsecured areas since it is virtually impossible to prevent against localized breach in conventional construction for package weapons placed on the floor.

Precast panels are problematic because of their tendency to fail at the connections. Pre- and post-tensioned systems tend to fail in a brittle manner if stressed much beyond their elastic limit. These systems are also not able to accept upward loads without additional reinforcement. If pre- and post-tensioned systems are used, continuous mild steel needs to be added to the top and the bottom faces to provide the ductility needed to resist explosion loads.

Flat slab/plate systems are also less desirable because of limited two-way action and the potential for shear failure at the columns. When flat slab/plate systems are employed, they should include features to enhance their punching shear resistance, and continuous bottom reinforcement should be provided across columns to resist progressive collapse. Edge beams should be provided at the building exterior.

**Interior Columns:** Interior columns in unsecured areas are subject to many of the same issues as exterior columns. If possible, columns should not be accessible within these areas. If they are accessible, then obscure their location to impose a standoff to the structural component through the use of cladding. Methods of hardening columns include using closely spaced ties, spiral reinforcement, and architectural covering at least six inches from the structural elements. Composite steel and concrete sections or steel plating concrete columns can provide higher levels of protection. Columns in unsecured areas should be designed to span two or three stories without buckling in the event that the floor below and possibly above the detonation area has failed, as previously discussed.

**Interior Walls:** Interior walls surrounding unsecured spaces are designed to contain the explosive effects within the unsecured areas. Ideally, unsecured areas are located adjacent to the building exterior so that the explosive pressure may be vented outward as well.

Fully grouted CMU (concrete masonry unit) block walls that are well reinforced vertically and horizontally and adequately supported laterally are a common solution. Anchorage at the top and bottom of walls should be capable of developing the full flexural capacity of the wall. Lateral support at the top of the walls may be achieved using steel angles anchored into the floor system above. Care should be taken to terminate bars at the top of the wall with hooks or heads and to ensure that the upper course of block is filled solid with grout. The base of the wall may be anchored by reinforcing bar dowels.

Interior walls can also be effective in resisting progressive collapse if they are designed properly with sufficient load-bearing capacity and tied into the floor systems below and above.

This design for hardened interior wall construction is also recommended for primary egress routes to protect against explosions, fire, and other hazards trapping occupants.

### 5.1.6 Structural Materials

All structural materials and types acceptable under the *North Carolina Building Code* may be used. However, special consideration should be given to materials that have inherent flexibility and that are better able to respond to load reversals (i.e., cast-in-place reinforced concrete and
Careful detailing is required for material such as pre-stressed concrete, pre-cast concrete, and masonry (brick and concrete masonry unit) to adequately respond to the design loads. The construction type selected must meet all performance criteria of the specified level of protection.

In Section 4.5, fire protection of structural elements is discussed simply because this aspect of building design typically falls to the architect. *However, the structural engineer, in designing to mitigate blast and fire under terrorist attack, must take an active role in defining fire protection systems and required ratings.*

Structural steel protection is particularly important. Analysis of the World Trade Center collapse shows that the collapse resulted from the fire-weakened floors sagging and pulling the damaged perimeter structure inward; the building literally fell in on itself. Better fire rating for the floor structural system may have prevented this from occurring and NIST currently recommends a passive fire protection rating of four hours for structural systems in buildings three stories and more.

Much more fire resistance research for steels has been done in Europe (the U.K., Denmark, Finland, etc.) and in Japan than in the United States. In the U.K., fire resistance is usually expressed in terms of compliance with a test regime outlined in British Standard BS476 Part 20 and 21 (11). *It is a measure of the time taken before an element of construction exceeds specified limits for load carrying capacity, insulation and integrity.* These limits are clearly defined in the standard. The characteristics of the time-temperature relationship for the test fire from BS476 are shown in the following figure, where temperature is given in °C:

All materials become weaker when they get hot. The strength of typical structural steel at high temperature has been defined in great detail and it is known that at a temperature of 550°C structural steel will retain 60% of its room temperature strength, as shown by the following figure, where the temperature is given in °C:
This is important because, before the introduction of limit state design concepts, when permissible stress was used as a basis for design, the maximum stress allowed in a member was about 60% of its room temperature strength. This led to the commonly held assumption that 550°C (equivalent to 1,000°F) was the highest or "critical" temperature that a steel structure would withstand before collapse.

Recent international research has shown, however, that the limiting (failure) temperature of a structural steel member is not fixed at 550°C, but varies according to two factors, the temperature profile and the load.

Research has shown that the temperature profile through the cross-section of a steel structural member has a marked effect on its performance. The effect of temperature on yield strength is characterized by results obtained from small-scale tensile tests.

The basic high temperature strength curve shown in the figure above was generated by testing a series of small samples of steel in the laboratory, where the whole of each test sample is at a uniform temperature and is axially loaded. The effect of a non-uniform temperature profile is to allow redistribution of stresses from hot parts of the cross-section to cooler areas.

When these conditions are repeated in full-scale member tests, e.g. unprotected axially loaded columns, then failure does indeed occur at 550°C.

But if a member is not uniformly heated then, when the hotter part of the section reaches its limiting temperature, it will yield plastically and transfer load to cooler regions of the section, which will still act elastically. As the temperature rises further more load is transferred from the hot region by plastic yielding until eventually the load in the cool regions becomes so high that they too becomes plastic and the member fails.

The top flange of a beam supporting a slab remains cooler than the web and lower flange, which results in an increase in critical temperature to about 620°C (1,150°F).

The most common situation in which temperature gradients have a significant effect on the fire resistance of structural steel is where beams support concrete slabs. The effect of the slab is both to protect the upper surface of the top flange of the beam from the fire and to act as a heat
sink. This induces temperature differences of up to 200°C between the upper and lower flanges in standard fire tests. Test data shows that the limiting (lower flange) temperature of fully loaded beams carrying concrete slabs is about 620°C. This compares with 550°C for beams exposed on all four sides.

Beams fail when the applied bending moment is equal to the plastic moment of resistance, reduced to account for temperature. Lower loads or stronger beams will therefore result in increased failure temperatures.

It is known from full-scale fire tests that a simply supported beam carrying a concrete floor slab and 60% of its cold load bearing capacity will become plastic at about 620°C. It is also known that if it carries a lower load then plasticity will occur at a higher temperature. Thus, at low loads fire resistance is increased.

In BS5950 Part 8 (12), load is expressed in terms of the “Load Ratio,” where Load Ratio equals the load at the fire limit state divided by the load capacity at 20°C.

The load at the fire limit state is calculated using load factors given in BS5950 Part 8. A fully loaded beam in bending would normally have a load ratio of about 0.50 - 0.6. It is known from the research data that, with a load ratio of 0.25, for example, failure in simply supported beams carrying concrete slabs will not occur until the steel reaches 750°C, an increase of 130°C on the limiting temperature in the fully loaded case.

In Japan (and other seismically active regions), conventional low-carbon structural steel is often replaced with stronger, heat resistant steels that are rarely (if ever) used in the United States. These steels can increase the load/temperature performance of the steel by 25-30%, as shown in the following figure:

![Diagram showing load/temperature performance of conventional and fire-resistant structural steels.]

5.2 DESIGN REFERENCES AND RESOURCES

All building components requiring blast resistance should be designed using established methods and approaches for determining dynamic loads, structural detailing, and dynamic
structural response. Design and analysis approaches should be consistent with those in the American Society of Civil Engineers ASCE 7-2002, *Minimum Design Loads for Buildings and Other Structures*. Alternative analysis and mitigation methods can be used, provided that the performance level is attained. A peer group should evaluate new and untested methods.

The following references are recommended to aid in the design:


American Institute of Steel Construction, April 2005, *Facts for Steel Buildings No. 2, Blast and Progressive Collapse*
5.3 STRUCTURES CHECKLIST


   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 a 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 unreinforced. A quick 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, where a higher score indicates a greater capacity to sustain load reversals:

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Score Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood buildings of all types</td>
<td>4.5 to 8.5</td>
</tr>
<tr>
<td>Steel moment-resisting frames</td>
<td>3.5 to 4.5</td>
</tr>
<tr>
<td>Braced steel frames</td>
<td>2.5 to 3.0</td>
</tr>
<tr>
<td>Light metal buildings</td>
<td>5.5 to 6.5</td>
</tr>
<tr>
<td>Steel frames with cast-in-place concrete shear walls</td>
<td>3.5 to 4.5</td>
</tr>
<tr>
<td>Steel frames with unreinforced masonry infill walls</td>
<td>1.5 to 3.0</td>
</tr>
<tr>
<td>Concrete moment-resisting frames</td>
<td>2.0 to 4.0</td>
</tr>
<tr>
<td>Concrete shear wall buildings</td>
<td>3.0 to 4.0</td>
</tr>
<tr>
<td>Concrete frames with unreinforced masonry infill walls</td>
<td>1.5 to 3.0</td>
</tr>
<tr>
<td>Tilt-up buildings</td>
<td>2.0 to 3.5</td>
</tr>
<tr>
<td>Precast concrete frame buildings</td>
<td>1.5 to 2.5</td>
</tr>
<tr>
<td>Reinforced masonry</td>
<td>3.0 to 4.0</td>
</tr>
<tr>
<td>Unreinforced masonry</td>
<td>1.0 to 2.5</td>
</tr>
</tbody>
</table>

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? 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?**

   These structural elements contribute significantly to the survivability of the structure during an explosion.

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.

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 buildings 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.

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, as follows:


*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 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 one 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.

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 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 six-inch standoff 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?
Design to mitigate progressive collapse is an independent analysis to determine a systems ability to resist structural collapse upon the loss of a major structural element or the systems ability to resist the loss of a major structural element. Design to mitigate progressive collapse may be based on the methods outlined in ASCE 7-02. Designers may apply static and/or 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.

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.

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.

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 standoff distance available and postulated design threat. Walls should be fully grouted and reinforced CMU construction where CMU is selected. Unreinforced masonry walls should never be used for the exterior walls of new buildings. A minimum of 0.05 percent vertical reinforcement with a maximum spacing of 48 inches should be provided for a low level of protection; more reinforcing is required for higher levels of protection.

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.

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.
6 DESIGNING FOR TERRORISM: MECHANICAL SYSTEMS

6.1 HVAC DESIGN TO MINIMIZE EXPLOSIVE THREATS

In the event of an explosion directed at a high occupancy building, the primary design objective is to protect the people by preventing building collapse and, for the HVAC designer, limiting injuries due to flying debris and the direct effects of the blast pressure wave entering the building. Next, the HVAC design should facilitate building evacuation and rescue efforts.

The key concepts for providing secure and effective mechanical systems in buildings are separation, hardening, and redundancy:

**Separation:** Separation begins with keeping critical mechanical systems as far away from high-threat areas of the building, including lobbies, loading docks, mail rooms, garages, and retail spaces...anywhere an explosive device can be delivered and detonated easily. To help meet this goal, mechanical equipment rooms should be constructed of solid masonry walls (or at least reinforced CMU properly anchored to the structural system) and have secured access.

**Hardening:** Physical "hardening" or protection of critical piping, ductwork, electrical power and control wiring conduit, etc. will help ensure the survival of these systems from direct blast effects. Route piping, conduit, and ductwork so they are not located in or on exterior walls and avoid close proximity to high-threat areas of the building. Support piping, conduit, and ductwork to meet the seismic design requirements of the 2006 North Carolina Building Code, Section 1621.

Outdoor air intakes should be designed to eliminate a direct, linear path between the outdoors and critical HVAC mechanical equipment to mitigate blast pressure wave effects. This can be accomplished by designing (1) outdoor intake plenums that are constructed of concrete masonry and (2) connections to these plenums at 90° from the intake airflow direction.

**Redundancy:** Redundant critical systems and controls, installed in widely separated locations, increase the likelihood that these systems will remain operation during the rescue period.

Safe haven areas and exit stairways in multi-story buildings should be designed as smokeproof enclosures in accordance with Section 909.20 of the 2006 North Carolina Building Code. The
important role for HVAC systems is to provide the necessary pressurization and venting required to maintain a smoke free environment in these areas to aid in protecting building occupants who cannot escape and those that exit the building after an attack.

From Section 909.20, the following design requirements apply:

1. Pressurize these areas to 0.10 in. WG, with all doors closed and under maximum stack effect pressures;

2. Ventilation systems must be activated by smoke detectors at the entrance to the smokeproof enclosure;

3. Ventilation systems serving smokeproof enclosures must be independent of the building normal HVAC systems;

4. All ventilation equipment, ductwork, etc. must be protected by two-hour fire-resistance-rated fire barriers;

5. The ventilation equipment must be served by the standby power system; and

6. The system must be tested and approved by the local code official.

In addition, all HVAC air systems should be designed to operate in a "smoke evacuation mode." This mode can be initiated by a signal from the fire alarm system, but the design should also include an emergency manual selector switch so that authorities can operate the systems in this mode or simply shut them down. In the smoke evacuation mode, each system's outdoor damper and relief air damper shall open fully and the return damper close. If the system is the VAV type, the fans should be indexed to provide maximum airflow. All building exhaust systems should continue to operate while in this mode.

6.2 HVAC DESIGN TO MINIMIZE CBR THREATS

HVAC systems design elements required to address CBR threats fall into three categories: (1) reduce the potential that airborne CBR agents can enter the building, (2) zoning and HVAC systems control to limit the air distribution of CBR agents that may be released internally, and (3) air cleaning to reduce CBR concentration levels:

6.2.1 Prevent CBR Agents from Entering the Building

Airborne CBR agents can enter the building from the outdoors by being released into the air close to a building entrance or into the outdoor air intake of an HVAC system. To reduce the potential for these types of attacks, the HVAC design should be such that (a) the building is maintained at a positive pressure and (b) outdoor air intakes are protected. High-threat areas in a building (lobbies, loading docks, mail rooms, garages, and retail spaces) should be maintained at a negative pressure relative to the rest of the building, but at a positive pressure relative to the outdoors, to prevent the spread of internally-released CBR agents. Return air intakes represent another potential access point for introducing CBR agents.
Building and Space Pressurization: Building pressurization is most easily accomplished by ensuring that the amount of outdoor introduced through each HVAC air system exceeds the exhaust airflow in the area served by that system by at least 10-20%.

High-threat areas require an anteroom or vestibule at each exterior entrance to maintain the dual pressure requirement. While the high-threat area is maintained at a negative pressure relative to the surrounding building, the anteroom must be maintained at a positive pressure to prevent externally released CBR agents from entering.

Outdoor Air Intakes: One of the most important steps in protecting a building’s indoor environment is the security of the outdoor air intakes. Outdoor air enters the building through these intakes and is distributed throughout the building by the HVAC system. Introducing CBR agents into the outdoor air intakes allows a terrorist to use the HVAC system as a means of dispersing the agent throughout a building. Publicly accessible outdoor air intakes located at or below ground level are at most risk due partly to their accessibility and partly because most CBR agent releases near a building will be close to the ground and may remain there. Securing the outdoor air intakes is a critical line of defense in limiting an external CBR attack on a building.

Outdoor air intakes should be located on a secure roof or high sidewall. The lowest edge of the outdoor air intakes should be placed at least 12 feet above the ground or above any nearby accessible level (i.e., adjacent retaining walls, loading docks, handrails, etc.) Also, the entrance to the intake should be covered with a sloped metal mesh or louver to reduce the threat of objects being tossed into the intake. A minimum slope of 45° is generally adequate.

Return Air Intakes: HVAC return grilles that are publicly accessible and not easily observed by security personnel may be vulnerable to a CBR agent release. HVAC return grilles should always be located in areas that are inaccessible or are under security surveillance. Return air plenums in public areas or high-threat areas should not be interconnected with return plenums in the remainder of the building.

Ducted return systems offer limited access points for introducing CBR agents, while any point in the ceiling of a ceiling return plenum can be used for access. Therefore, ducted return systems are recommended. Even then, the return system should be designed so that it is not shared by multiple air-handling systems.
6.2.2 HVAC Systems Zoning and Control

Certain areas within a building are more likely to be the entry points for CBR agents, including lobbies, mailrooms, and other receiving areas, along with public spaces, including retail. These areas should have HVAC air systems that are totally independent from the rest of the building and from other high-threat areas.

Theoretically, automatic CBR agent detectors can be used to initiate protective actions such as shutdown of ventilation systems, closing outside air intakes, or turning on filtration systems. Detection of radiological agents can be performed with off-the-shelf equipment. Current biological detection technology requires a minimum delay of approximately 15 minutes to detect the presence of biological agents. Practical application of chemical detection is limited by shortcomings in response time, false alarms, broad-spectrum capability, maintenance requirements, cost, and the quantity of sensors needed at air intake locations. For terrorist threats, no audible and visual indications announce the attack other than incapacitation of people. Thus, application of detectors for terrorist threats should be limited to the following uses: first entry determination by first responders, monitoring casualties before medical treatment, determining the extent of the hazard, and determining when protective measures are no longer required.

6.2.3 Air Cleaning

Filters (air cleaners) are applied in air-handling systems to remove particulate contaminants and pollutants from the air. “Respirable” particulates, particulates that enter the lungs, are defined as those 10 microns or less in diameter, though the EPA has defined particles smaller than 3.5 microns as a particular problem with deep lung penetration. Particles larger than 10 microns may also be contaminants, but generally cannot be directly inhaled.

ASHRAE Standard 52.2, issued in 1999, totally revamped the methodology of rating and applying filters in HVAC systems by establishing minimum efficiency rating values (MERV) for filters and a test method for determining the MERV. The table on the following page summarizes the application guidelines for each type of filter and establishes a range of recommended MERV’s. This table can be used to select and specify air cleaner performance required for HVAC applications and for anti-CBR duty.

“Electrostatic filters,” passive residential filters, are ranked at the low end of the MERV scale, despite claims by the manufacturers that this type of filter is both effective and reliable. The standard recognizes that these claims are, at best, exaggerated and the filters do not perform well or reliably in HVAC systems.

“Active” electrostatic or electronic filters are very efficient, with an MERV of 12-15 when they are properly operated and maintained. However, in most commercial and institutional applications, the regular maintenance required to ensure proper filter performance is seldom provided. Internal filter failures (electrical breaks, etc.) and simply particulate “loading” on the attractor plates reduce filter performance and, since there is no obvious indication of these failures, poor performance can occur over long periods of time. Therefore, unless the owner is aware of and committed to the required maintenance, this type of filter should not be used.

Particulate filtration is the first step in CBR agent cleaning. Under normal circumstances, biological agents can be collected using appropriately selected particulate filters, based on the type of agent and its particle size:
Almost any level of filtration will capture particles 10 microns and larger. Biological agents can be captured with 99+\% efficiency with the following filter ratings:

<table>
<thead>
<tr>
<th>Aerodynamic Diameter (µm)</th>
<th>Example Biological Particle</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10</td>
<td>Large fungal spores</td>
</tr>
<tr>
<td>2.5 - 10</td>
<td>Larger bacteria and typical fungal spores</td>
</tr>
<tr>
<td>0.5 - 2.5</td>
<td>Smaller bacteria (anthrax) and their spores</td>
</tr>
<tr>
<td>0.01 - 0.5</td>
<td>Viruses, allergenic components of fungi or bacteria</td>
</tr>
</tbody>
</table>

For radiological agents, air-cleaning devices would be ineffective at stopping any blast and radiation itself; however, they would be useful in collecting the material from which the radiation is being emitted. Micrometer-sized aerosols from a radiological event are effectively removed from air streams by HEPA filters (MERV 17-20). This collection could prevent distribution throughout a building; however, subsequent decontamination of the HVAC system would be required.

For chemical agents, including industrial hazardous chemicals, gas phase air cleaning is required. Blister and nerve agents are strongly adsorbed by activated carbon. Blood and choking agents are not strongly retained by activated carbon, but additives, such as metal oxides and other reactants found in the U.S. military carbon ASZM-TEDA, may be used in the sorbent to degrade the hazard.
<table>
<thead>
<tr>
<th>Std. 52.2 Minimum Efficiency Reporting Value (MERV)</th>
<th>Approx. Std. 52.1 Results</th>
<th>Duct Spot Efficiency</th>
<th>Arrestance</th>
<th>Typical Controlled Contaminant</th>
<th>Typical Applications and Limitations</th>
<th>Typical Air Filter/Cleaner Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>N/A</td>
<td>N/A</td>
<td>0.30 µm Particle or Smaller</td>
<td>Cleanrooms</td>
<td>HEPA/ULPA Filters ≥99.999% efficiency on 0.10-0.20 µm particles, IEST Type F ≥99.999% efficiency on 0.30 µm particles, IEST Type D ≥99.99% efficiency on 0.30 µm particles, IEST Type C ≥99.97% efficiency on 0.30 µm particles, IEST Type A</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>N/A</td>
<td>N/A</td>
<td>Virus (unattached)</td>
<td>Radioactive materials</td>
<td>Box Filters Nonsupported (flexible) microfine fiberglass or synthetic media. 300 to 900 mm (12 to 36 in.) deep, 6 to 12 pockets.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>N/A</td>
<td>N/A</td>
<td>Carbon dust</td>
<td>Pharmaceutical manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>N/A</td>
<td>N/A</td>
<td>Sea salt</td>
<td>Carcinogenic materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>N/A</td>
<td>N/A</td>
<td>All combustion smoke</td>
<td>Orthopedic surgery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>&gt;95%</td>
<td>N/A</td>
<td>Radon progeny</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>90-95%</td>
<td>&gt;98%</td>
<td>0.30 - 1.0 µm Particle</td>
<td>Hospital inpatient care</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>80-90%</td>
<td>&gt;98%</td>
<td>Most bacteria</td>
<td>General surgery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>70-75%</td>
<td>&gt;95%</td>
<td>Legionella</td>
<td>Smoking lounges</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>60-65%</td>
<td>&gt;95%</td>
<td>Humidifier dust</td>
<td>Superior commercial buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>50-55%</td>
<td>&gt;95%</td>
<td>Lead dust</td>
<td>Hospital laboratories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>40-45%</td>
<td>&gt;90%</td>
<td>Milled flour</td>
<td>Schools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>30-35%</td>
<td>&gt;90%</td>
<td>3.0-10.0 µm Particle</td>
<td>Superior residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>25-30%</td>
<td>&gt;90%</td>
<td>Mold</td>
<td>Better commercial buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>&lt;20%</td>
<td>85-90%</td>
<td>Spores</td>
<td>Hospital laboratories</td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td>&lt;20%</td>
<td>80-85%</td>
<td>Hair spray</td>
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<td>4</td>
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<td>75-80%</td>
<td>10.0 µm Particle</td>
<td>Commercial buildings</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>&lt;20%</td>
<td>70-75%</td>
<td>Pollen</td>
<td>Better residential</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>&lt;20%</td>
<td>65-70%</td>
<td>Spanish moss</td>
<td>Industrial workplaces</td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>&lt;20%</td>
<td>&lt;65%</td>
<td>Dust miles</td>
<td>Smoke booth inlet air</td>
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<td>Sanding dust</td>
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<td>Spray paint dust</td>
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<td></td>
<td></td>
<td>Textile fibers</td>
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<td>Carpet fibers</td>
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<td></td>
<td>Minimum filtration</td>
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<td></td>
<td>Residential</td>
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<td></td>
<td></td>
<td></td>
<td>Window air conditioners</td>
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<td></td>
<td></td>
<td></td>
<td>Electrostatic</td>
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<td></td>
<td></td>
<td></td>
<td>Self charging (passive) woven polycarbonate panel filter</td>
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</table>
Gas-phase air cleaning devices are sorbent filters, designed to remove pollutant gases and vapors from the building environment. Sorbents use one of two mechanisms for capturing and controlling gas-phase air contaminants, physical adsorption and chemisorption. Both capture mechanisms remove specific types of gas-phase contaminants from indoor air. Unlike particulate filters, sorbents cover a wide range of highly porous materials, varying from simple clays and carbons to complexly engineered polymers. Many sorbents, not including those that are chemically active, can be regenerated by application of heat or other processes.

The process of “absorption” can also accomplish gaseous air cleaning where the pollutant molecules (along with water vapor molecules) merge into the filter media, similar to liquid phase mixtures. The absorption process produces ionization, enabling chemical reaction to occur. To enhance this process, sorbents can be impregnated with specific reagents to enhance their ability to chemically react with specific gaseous pollutants.

Ozonization is also used for gas phase control. Ozone is highly unstable and therefore, a reactive compound that, when released into the air stream, can chemically modify reactive molecules with which it comes in contact. This process may be used with a sorption media bed to improve overall performance and provide a method of controlling the amount of residual airborne ozone.

Typical sorption media commercially available include the following:

1. Carbon
2. Impregnated or Activated Carbon
3. Alumina/Potassium Permanganate (KMnO₄)
4. Zeolite
5. Zeolite/ KMnO₄
6. Various blends of these media

There are no universal test methods of rating and selecting chemical filters. However, the following general guidelines can be applied:

1. Carbon is best applied against contaminants that are higher in concentration, heavier in molecular weight, and nonpolar and that have a higher molecular carbon content. This includes most VOC’s and long molecular chain hydrocarbons. It also works best at lower temperature and humidity conditions.

2. Alumina/Potassium Permanganate (KMnO₄) modified media perform best against lower molecular weight compounds, polar compounds such as formaldehyde, and reactive inorganic compounds such as hydrogen sulfide and sulfur dioxide.

3. Zeolite is particularly effective as a cation exchange media. This makes it perform well against contaminants such as ammonia and other nitrogen bearing compounds. It also has a higher surface area than alumina compounds.

Understanding the precise removal mechanism for gases and vapors is often difficult due to the nature of the adsorbent and the processes involved. While knowledge of adsorption equilibrium helps in understanding vapor protection, sorbent performance depends on such properties as mass transfer, chemical reaction rates, and chemical reaction capacity. Some of the most important parameters of gas-phase air cleaning include the following:
Breakthrough Concentration: the downstream contaminant concentration above which the sorbent is considered to be performing inadequately. Breakthrough concentration indicates the agent has broken through the sorbent, which is no longer giving the intended protection. This parameter is a function of loading history, relative humidity, and other factors.

Breakthrough Time: the elapsed time between the initial contact of the toxic agent at a reported challenge concentration on the upstream surface of the sorbent bed, and the breakthrough concentration on the downstream side of the sorbent bed.

Challenge Concentration: the airborne concentration of the hazardous agent entering the sorbent.

Residence Time: the length of time that the hazardous agent spends in contact with the sorbent. This term is generally used in the context of superficial residence time, which is calculated on the basis of the adsorbent bed volume and the volumetric flow rate.

Mass Transfer Zone or Critical Bed Depth: interchangeably used terms, which refer to the adsorbent bed depth required to reduce the chemical vapor challenge to the breakthrough concentration. When applied to the challenge chemicals that are removed by chemical reaction, mass transfer is not a precise descriptor, but is often used in that context. The portion of the adsorbent bed not included in the mass transfer zone is often termed the capacity zone.

Before selecting an air cleaning strategy, you will need to evaluate potential CBR threats, ventilation/filtration requirements, and indoor air quality. The answers to these questions will guide in making decisions about what types of filters and sorbents (if any) should be installed in and HVAC system, how efficient those filters and/or sorbents must be, and what procedures must be developed to maintain them after installation.

Based on current military requirements, high-risk facilities should be protected with Class II CBR filtration systems. This class of protection is applicable to a terrorist attack with little or no warning that produces a short duration small-scale release of agent. Under this concept, outside air intakes are protected by continuously operating CBR filtration units. The filtration system is sized for the normal facility air intake requirements.

The CBR filtration system is required to provide an overpressure that prevents the penetration of agents through the building envelope at wind speeds of 7mph, equivalent to 0.02 inch wg, which can be achieved by supplying a higher rate of conditioned fresh air to facility than is exhausted. Care should be taken during design and construction to ensure that a complete air barrier is included in the envelope construction and that proper sealing of penetrations. As discussed earlier, a whole building air infiltration test of the envelope should be performed after construction to verify the leakage rate and ensure that the overpressure system has sufficient capacity.

An airlock for ingress and egress into the mission critical areas is not required, but a vestibule that acts as an airlock is desirable to maintain overpressure. An internal or external contamination control area is also not required for Class II facilities.

The military Class II CBR filtration system consists of the following elements:

Roughing Filter: Continuously operated filter systems will have a roughing filter with an average efficiency of 25 to 30 percent when tested in accordance with ASHRAE 52.1 (MERV=
7). The roughing filter extends the life of the intermediate filter or prefilter and reduces its change frequency.

**Prefilter**: The prefilter or intermediate filter will have an average efficiency of 80 to 85 percent when tested in accordance with ASHRAE 52.1 (MERV=13). The prefilter extends the life of the HEPA filter and reduces its change frequency, though annual replacement is required.

**HEPA Filter**: The HEPA filter frame and filter media will meet the construction, material, testing, qualification, and documentation requirements of ASME N509, ASME N510, and UL 586 and will have a filter efficiency of 99.97 percent at a 0.3 Fm diameter partial size (MERV=20) when tested in accordance with the MIL-STD-282 dioctyl phthalate (DOP) test method. The filter frames meet the requirement of ASME AG-1a, section FC.

**Adsorption Filter**: The adsorber carbon media will be designed to adsorb aerosol with a minimum residence time of 0.25 seconds, which, for commercial filters, typically requires two-stage filtration. For unknown threats and adsorption of volatile agents, ASZM-TEDA carbon should be used.

Filter maintenance and replacement is critical to maintaining reliable threat mitigation. The roughing filter and prefilter should be replaced when the static pressure drop across the filter reaches the manufacturers recommended maximum "dirty" level. For HEPA filters, there are two criteria that dictate the need for replacement, pressure drop and age:

1. **Pressure Drop**: HEPA filters should be removed from service before the pressure drop across the filter exceeds 5" WG when normalized to the rated flow of the filter, based on the following relationship:

   \[
   DP_n = DP_m \left( \frac{F_{\text{rated}}}{F_{\text{measured}}} \right)
   \]

   Where

   - \(DP_n\) = Normalized pressure drop (in. WG)
   - \(DP_m\) = Measured pressure drop (in. WG)
   - \(F_{\text{rated}}\) = Rated airflow (CFM)
   - \(F_{\text{measured}}\) = Actual airflow (CFM)

2. **Age**: Studies show that the tensile strength of new filter media is directly proportional to the pressure drop at which the filter shows structural failure at the pleats. By applying this relationship to aged HEPA filters, the minimum pressure resulting in structural damage to the filter decreases with age. Under dry conditions, the filter media will fail the required strength test after 7 to 13 years, or at an average life of 10 years. Therefore, **HEPA filters operating under dry conditions should be replaced every 10 years**. Under wet (water sprays or rain penetration) conditions, the strength of the filter media is further decreased, decreasing filter life to 3 to 7 years, or an average life of 5 years. Therefore, **HEPA filters operating under wet conditions should be replaced every 5 years**. (Note that the term "wet" does not mean "soaked." Any HEPA filter that has become soaked should be replaced immediately.)

Some CBR agents may be attacked by UV radiation. The ability of UV radiation, a portion of the electromagnetic spectrum from 100nm-400nm, to inactivate biological pathogens has long been known. UV radiation works by damaging the DNA and other cell components of a
microorganism to the point that the cell cannot replicate. Cells that have been exposed to UV may still be viable, they just can't replicate, and therefore they are not infectious. Ultra Violet Germicidal Irradiation (UVGI) generally refers to UV wavelength of 254.7 nm. The wavelength is near optimal for damaging nucleic acid (DNA, RNA). UV irradiation by itself does not clean air. The microorganisms are still there, and in the case of some microorganisms, may still contain the ability to cause noninfectious (e.g. allergenic) disease. While there is potential for UV to destroy allergenic sites on the surface of a bioaerosol, this ability has not been documented or quantified.

UV irradiation is commonly used in the disinfection of drinking water. Although to a lesser extent, UV has also been used in the disinfection of air, mostly in healthcare settings. Anecdotal health information as well as laboratory research suggests it is an effective technology for inactivating airborne viruses and bacteria and their spores. However, there is a significant difference between addressing disease-causing organisms in a laboratory setting and ensuring that deadly biological warfare pathogens are completely removed from an airstream. Installation, construction, and design of UV systems must be of paramount importance, and a focus of air decontamination must now include securing air streams in ducts and HVAC systems from outside infiltration. Since the threat of this kind of terrorism has only recently been realized, independent scientific investigators have begun to do fundamental research into the biological decontamination of airstreams to update this science.

In November 2002, a major research study funded in part by the U.S. Department of Energy attempted to determine the effectiveness of UV germicidal radiation in inactivating bacteria and spores in a “typical” HVAC duct environment. The results were encouraging with inactivation effectiveness greater than 90% for bacteria, although efficacy was less for more resistant bacterial and fungal spores. Viruses were not tested in the study, but research in the laboratory indicates that a highly UV-resistant virus (bacteriophage MS2) is less resistant to UV radiation (in air) than bacterial Bacillus spores (regarded as the most resistant bacteria to UV radiation).

Laboratory research has determined that air temperature, relative humidity, flow rate, lamp design, and ballast engineering all have significant impacts on the effectiveness of these systems. Furthermore, the location of the decontamination UV array is of crucial importance because of the potential for air eddies and corners of ducting to allow some of the flow to pass through untreated. HVAC systems designers and control contractors will have to factor these components into their plans and base decontamination systems designs on tested parameters in order to ensure maximum effectiveness. Because of the constant airflow in modern ventilation systems, making this work in an HVAC system requires coordination between dampers (in order to slow the passage of the air enough to allow all particles to receive a sanitizing ray of UV light) and the UV light itself. While this kind of attention to detail might not be necessary in installations primarily concerned with improving the day-to-day healthiness of air, in order to control the spread of a deadly bio-terrorist pathogen (such as anthrax or smallpox), the design of a UVGI system is of critical importance.

The EPA has issued several warnings concerning UVGI companies that make unsubstantiated claims as to the effectiveness of their technology. For example, be careful of reports by sterilization and decontamination companies making claims such as "the simultaneous emission of ultrasound or ultrasonic waves and ultraviolet light complement each other and can effectively sterilize either organic or inorganic items in a non-liquid environment." No white paper or peer reviews have ever been published confirming these claims. The public is advised to use proven methods of controlling indoor air pollution.
6.3 EMERGENCY PLANS, TRAINING, AND PROCEDURES FOR HVAC SYSTEMS.

All buildings should have current emergency plans to address fire, weather, and other types of emergencies. In light of past U.S. experiences with anthrax and similar threats, these plans should be updated to consider CBR attack scenarios and the associated procedures. Emergency plans should have procedures for communicating instructions to building occupants, identifying suitable shelter-in-place or safe haven 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 building occupants and emergency responders should all be addressed. The plans should be as comprehensive as possible but, as described earlier, protected by limited and controlled access. When appropriately developed, these plans, policies, and procedures can have a major impact upon occupant survivability in the event of a CBR release. Staff training, particularly for those with specific responsibilities during an event, is essential and should cover both internal and external events. Holding regularly scheduled practice drills, similar to the common fire drill, allows for plan testing, as well as occupant and key staff rehearsal of the plan, and increases the likelihood for success in an actual event. For protection systems in which HVAC control is done via the energy management and control system, emergency procedures should be exercised periodically to ascertain that the various control options work (and continue to work) as planned.

Periodic training of HVAC maintenance staff in system operations and maintenance should be conducted. This training should include the procedures to be followed in the event of a suspected CBR agent release. Training should also cover health and safety aspects for maintenance personnel, as well as the potential health consequences to occupants of poorly performing systems. Development of current, accurate HVAC diagrams and HVAC system labeling protocols should be addressed. These documents can be of great value in the event of a CBR release.

Procedures and preventive maintenance schedules should be implemented for cleaning and maintaining ventilation system components. Replacement filters, parts, etc., should be obtained from known manufacturers and examined prior to installation. It is important that ventilation systems be maintained and cleaned according to the manufacturer’s specifications. To do this requires information on HVAC system performance, flow rates, damper modulation and closure, sensor calibration, filter pressure loss, filter leakage, and filter change-out recommendations. These steps are critical to ensure that protection and mitigation systems, such as particulate filtration, operate as intended.

6.4 PLUMBING SYSTEMS

Plumbing systems can suffer significant damage when subjected to the shock of an explosion. Some of these utilities may be critical for safely evacuating personnel from the building or their destruction could cause damage that is disproportionate to other building damage resulting from an explosion. To minimize the possibility of the above hazards, apply the following measures:
1. Route critical or fragile utilities (water, gas, etc.) so that they are not on exterior walls or on walls shared with mailrooms.

2. Where redundant utilities are required in accordance with other requirements or criteria, 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.

3. Mount all overhead utilities and other fixtures weighing 30 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. Support plumbing piping to meet the seismic design requirements of the 2006 North Carolina Building Code, Section 1621.

4. To limit opportunities for aggressors placing explosives underneath buildings, ensure that access to crawl spaces, utility tunnels, etc. is secure.

6.5 FIRE SPRINKLER SYSTEMS

Normally, fire sprinkler systems are designed taking into account the types of sources and the fire load present. It is generally assumed that the sprinkler system will operate and contain a fire or slow its growth; smoke control systems will maintain a safe means of egress; and alarm systems will properly provide warnings allowing occupants to safely exit the building. A terrorist event is a far different scenario. Bomb blasts quickly cause widespread fire, damage, and large amounts of smoke, which can potentially overwhelm a properly functioning system. To further complicate the issue, it is possible that some of the system might be damaged during a bomb blast, thereby hindering a safe evacuation.

The sprinkler system is the first line of defense in controlling a fire after a blast. However, sprinkler systems are generally designed with a rate of water flow that will serve a zone of 1,500 square feet at a time. In a bomb blast situation, the area affected could easily exceed 1,500 square feet, and the resulting fire would overwhelm a code compliant sprinkler system. In addition, many sprinkler pipes would likely be damaged by a blast, causing the sprinkler system to be inoperative in the affected areas.

To further complicate the situation, sprinkler systems in taller buildings are combined with the building standpipe system. The standpipe system water supply is used by the fire department to connect their hoses to fight a fire. The damaged sprinkler piping would also make the standpipe system inoperative until the proper valves can be shut down to isolate the systems.

Both the standpipe and sprinkler systems generally share common distribution piping, supply piping, and fire pumps at the lowest level. Damage to any of these common elements can render the entire system non-functional.

Fire sprinkler design elements should include the following:

1. Redundant water services with check valves located where services combine to ensure independent operation in the event that one service is rendered inoperable.
2. Redundant distribution at the highest level of the building to enable operation in the event that a distribution riser is damaged.

3. Redundant fire pump/separately located fire pump rooms.

4. Separating the standpipe and sprinkler systems.

5. Routing of piping in hardened or safe areas.

6. Masonry walls for all stair shafts containing standpipes.

7. Supporting fire sprinkler piping to meet the seismic design requirements of the 2006 North Carolina Building Code, Section 1621.

6.6 MECHANICAL SYSTEMS CHECKLIST

HVAC:

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 and/or secured within fencing or enclosure. The fencing or enclosure should have a sloped roof to prevent the throwing of anything into the enclosure near the intakes. 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 (at least 10-12 feet) above the ground is preferred over a roof location. 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 degrees 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.

Exhausts are also a concern 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).

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 likely mechanical rooms when HVAC is installed. Adjacent structures or landscaping should not allow access to the roof.

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.

4. What are the types of air filtration? Include the efficiency and number of filter modules for each of the main air handling systems? Is there any collective protection for chemical, biological, and radiological contamination designed into the building?
Consider a mix of approaches for optimum protection and cost-effectiveness.

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.

6. **Are there provisions for air monitors or sensors for chemical or biological agents?**

Duct mounted sensors are usually 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.

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.

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.

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.

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.

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.

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.

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).

14. **Where are the building automation control centers and cabinets located? Are they in secure areas? How is the control wiring routed?**

Access to any component of the building automation and control system could compromise the functioning of the system, increasing vulnerability to a hazard or preclude their proper operation during a hazard incident. 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.

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.

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.

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.
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.

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.

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.

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.

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.

**Plumbing and Gas Systems:**

1. What is the method of water distribution? What is the method of gas distribution (heating, cooking, medical, process)?

Central shaft locations for piping are more vulnerable than multiple riser locations.

2. 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.

3. 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.

4. **Where are gas storage tanks located? 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.

5. **Are there reserve supplies of critical gases?**

Localized gas cylinders could be available in the event of damage to the central tank system.
7

DESIGNING FOR TERRORISM: ELECTRICAL AND SPECIAL SYSTEMS

7.1 ELECTRICAL POWER AND LIGHTING SYSTEMS

The major security functions of the electrical system are to maintain power to essential building services, especially those required for life safety and evacuation; provide lighting and surveillance to deter criminal activities; and provide emergency communications. Thus, the operability of electrical systems is an important element for deferring terrorist attacks and can become a critical component for life safety systems after an attack. Designers should consider the following recommendations for buildings requiring high security:

1. Emergency and normal electric panels, conduits, and switchgear should be installed separately, at different locations, and as far apart as possible. Electric distribution should be run from separate locations.

2. 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.

3. Fuel tanks should be mounted near the generator, given the same protection as the emergency generator, and sized to store an appropriate amount of fuel. A battery and/or UPS could serve a smaller building or leased facility.

4. Conduits and lines should be installed outside to allow a trailer-mounted generator to connect to the building’s electrical system. If tertiary power is required, other methods include generators and feeders from alternative substations.

5. Site lighting must be coordinated with the CCTV system.

6. Emergency lighting should be provided in restrooms and other "dead end" areas, in addition to the normal egress locations.

7. Building access points must be illuminated to aid in threat detection.
8. Self-contained battery lighting should be provided in stairwells and for exit signs.

9. Suspending electrical conduits from the ceiling should be avoided.

7.2 PHYSICAL SECURITY LIGHTING

Security lighting should be provided for overall site/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 by reducing opportunities for concealment and surprise by potential attackers. Lighting is particularly desirable for sensitive areas of a site such as pier and dock areas, vital buildings, storage areas, and vulnerable control points in communications, power, and water distribution systems. It facilitates detection of unauthorized personnel and makes the job of an attacker more difficult.

At entry control points, a minimum surface lighting average of four horizontal foot-candles will help ensure adequate lighting for pedestrians, islands, and guards. Where practical, high-mast lighting is recommended because it gives a broader and more natural light distribution, requires fewer poles (less hazardous to the driver), and is more aesthetically pleasing than standard lighting. Lighting of the entry control point should give drivers a clear view of the gatehouse and, for security personnel, it gives a clear view of the drivers and vehicles.

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

1. 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. Two primary methods of using continuous lighting are glare projection and controlled lighting:

   a. The glare projection security-lighting method lights the area surrounding a controlled area with high-intensity lighting. It is a strong deterrent to a potential intruder because it makes him or her very visible while making it difficult to see inside the secure area. Guards are protected by being kept in comparative darkness while being able to observe intruders at a considerable distance. This method should not be used when the glare of lights directed across the surrounding territory could annoy or interfere with adjacent operations.

   b. Controlled lighting is best when there are limits to the lighted area outside the perimeter, such as along highways. In controlled lighting, the width of the lighted strip is controlled and adjusted to fit the particular need. This method of lighting may illuminate or silhouette security personnel.
2. 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 security personnel or alarm systems.

3. Movable lighting consists of manually operated, movable searchlights that may be lit during hours of darkness or as needed. The system normally is used to supplement continuous or standby lighting.

4. 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.

### 7.3 Life Safety Systems

In the broad scope, building life safety systems should have the following minimum capabilities:

**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 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.

**Mass notification:** All inhabited buildings should have a timely means to notify occupants of threats and give instructions as to responses. Building communications systems should provide real-time notification of occupants and passersby in the immediate vicinity of the building during emergency situations. The information relayed should be specific enough to determine the appropriate response actions.

**Redundant communications:** The facility could have a second telephone service to maintain communications in case of an incident. A base radio communication 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 facility if required for emergency communications through wireless transmission of data.

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

The fire alarm system is required to notify the local fire department, initiate proper evacuation alarms, communicate with occupants, and activate automatic HVAC system sequences, including smoke control. This processing function generally comes together at the Fire Command Center (FCC). Should a bomb blast damage the FCC or the main fire alarm wiring serving the system, the fire department or facilities personnel or the system itself will be unable to determine the extent of the damage. Further, the fire alarm communication systems could not be used to communicate with building occupants on how best to evacuate. In addition, the smoke exhaust system that is designed to keep the egress path clear of smoke may not activate.
The following measures should be considered to enhance the reliability of the fire alarm system:

1. Distributed intelligent fire alarm panels connected in a peer-to-peer network that enables each data-gathering panel to function independently. Each panel can process alarms and initiate sequences within its respective zone.

2. Redundant fire command centers or blast-protected FCC.

3. Hardened and/or redundant main fire alarm wiring distribution with different routes and points of entry.

4. Hardened and/or redundant communications and public address systems, including potential wireless communications coordinated with fire department, police and emergency rescue communication capabilities.

The most critical element in keeping the life safety systems operational is power. It is possible or even likely that a bomb blast will knock out the utility power serving the building. This will leave the emergency generator as the source of power to operate smoke exhaust fans, fire pumps, emergency lighting, elevators, fire alarm system, and the public address system.

One of the major issues associated with the reliability of the emergency power system is the location of the emergency generator. Since the generator needs cooling air and combustion air, it is generally located at the exterior of the building. The louvers used by the generator make it impossible to blast-protect the room. Possible solutions include locating the generator in protected areas or using a combination of remote radiators and air conditioning to eliminate the intake louvers. Another solution might be to provide redundant generators at opposite ends of the building.

Further complicating the hardening of the emergency power system is the network of emergency power distribution, which runs throughout the building. The following approaches should be considered:

1. Redundant separate main distribution routing.

2. Routing feeders through secure locations.

3. Encasing feeders in concrete or hardened core areas.

4. Battery backup for emergency lighting.

The sound system is used in most venues for occupant notification. During an emergency condition, the fire alarm system interfaces with the sound system to provide automatic and/or manual verbal notification. The following items need to be addressed:

1. The fire alarm system must remain functional (see above).

2. The sound system control room must remain functional (should be in a hardened room with battery and/or emergency power backup).
3. The amplifiers must remain functional (consideration should be given to distributed amplification to lessen the likelihood of a single point of failure that would incapacitate the entire system).

4. All the interconnecting wiring must be protected and/or provided with redundancy.

5. The emergency power system must remain functional.


Should the power fail during an emergency situation, operational emergency lighting is imperative to minimize panic, as well as to allow occupants to find a safe means of egress. As with the sound system, the emergency lighting system has many of the same interfaces with the fire alarm and emergency power system that must be functional in order for the system to operate. The following issues should be addressed to enhance reliability, including:

1. Lighting control system (should be in a hardened room or have controls in separate locations).

2. Independent battery backup for emergency lighting and/or interconnecting wiring should be hardened or provided with redundant routing.

3. Power feeds should come from diverse areas of the building to lessen the likelihood of damage being sustained to the entire system.

During an emergency, it is likely that normal phones will be knocked out, cell phone networks will be overloaded, and police, fire, and EMS radios may not work in the building. Consideration should be given to:

1. Extra emergency phones separate from PBX or using failure/transfer mode to connect direct to a central office if PBX fails.

2. In-building repeater system for police, fire, and EMS radio.

3. Redundant or wireless fireman’s communications in building.

7.4 ELECTRONIC SECURITY SYSTEMS

The current digital revolution has fueled significant improvements and advances in closed-circuit television (CCTV), as well as in access control and intrusion detection systems. Changes in security requirements have been heavily influenced by the events of 9/11 when it became quite clear that security and first-responder personnel must know how many people are in a building at any given point in time and on a real-time basis. Keeping track of all those entering and leaving a building previously required a logbook updated by security personnel. However, that task has been largely replaced by the use of computerized access cards and CCTV systems, with most designs incorporating security systems that limit access and provide video on-demand, as well as detect and deter intruders from a single control center located on-site or possibly hundreds of miles away.
The guidelines for most security system designs utilize multiple layers or “rings” of protection that provide the greatest opportunity for detecting, evaluating, and responding to a threat. This multiple-layer design, which originates protection at the building’s perimeter, increases its level of security with each subsequent ring. The rings provide deterrence, detection, and delay, while the area between the rings provides for an incident response zone.

The first ring of security for a typical facility addresses site perimeter security and could include:

1. Microwave and/or infrared sensors to detect movement at the perimeter barriers.
2. Intercom systems that provide communication when requesting entry.
3. Card readers or other systems that authenticate and allow entry.
4. A color CCTV surveillance system with recording capability to view and record activity at the perimeter of the building, particularly at primary entrances and exits. A mix of monochrome cameras should be considered for areas that lack adequate illumination for color cameras. The following considerations apply when lighting systems are intended to support CCTV assessment or surveillance: field of view of the camera; lighting intensity levels; maximum light-to-dark ratio; scene reflectance; daylight-to-darkness transitions; camera mounting systems relative to lighting; spectral response of the camera; cold-start time; and restrike time.

The second ring addresses building access security and includes:

1. A combination of exterior doors and electric locks. Doors should be strong. Solid doors should be security rated, while glass doors should utilize laminated glass. Frame design must match the security rating of the door. Revolving doors, as shown in the following figure, can be used. Revolving doors can be automatically controlled to operate through use of card readers, scanners, etc. They also have the advantage of being programmable to act as “man traps” in the event of unauthorized entrance.
2. Card readers, number pads, scanners, etc. to control entry. Optical turnstiles, as shown in the following figure allow the ability to utilize the technology in a variety of applications.

For example, opticals can be purchased that:

- Are simply open lanes that allow people to pass through without the use of barriers;

- Can be supplied with “wing style” retractable barriers similar to what one would observe being used in transportation centers such as train stations; and

- Are available with retractable glass barriers that can be installed as low glass (37 inches high), medium glass (42 inches) or high glass (67 inches) – each of which open and close with every transaction. The glass height is measured from about three inches above floor level, and the cabinet itself is about 42 inches high and mounts to the floor.

3. CCTV cameras.

4. Metal detectors may be required for certain applications, particularly where high public traffic levels is expected, such as transportation centers, sporting venues, convention centers, courts, hospital emergency departments and main entries, etc. Revolving doors and optical turnstiles can be obtained that meet ADA requirements.
The third and final ring provides facility interior security and could include:

1. CCTV cameras.

2. Electronic locking devices for interior doors, including elevator doors.

3. Dual authentication readers (card and biometrics) for entry to the facility’s core assets, such as data centers, sensitive research labs, vaults, etc.

As the deployment of electronic security systems increases in buildings, so has the information that can be gathered and stored from these various systems. Cameras throughout the building can track and record the movement and whereabouts of personnel, thereby providing a record of all the areas that are accessed on a real-time basis. Access levels can be programmed to allow admittance to those areas that an individual is authorized to enter and deny entry to those in which they are not authorized. From this information, security can be immediately informed if someone attempts to enter an area they were not authorized to access since all granted and denied entries are logged to the access control system. Optical turnstiles in lobbies grant and deny access from the program access cards while providing a real-time count of all entries and exits from the building. Card readers can be used to call elevators to a specific floor, while readers placed inside the elevator cabs are used to restrict access on a floor-by-floor basis. Without the proper access level on your card, you may be able to call the elevator and stop at Floors 2, 3, 4, and 7, but you may need a higher level of access to have the elevator stop at Floor 6.

With this level of information available on a real-time basis, it is possible to integrate the operations of various departments together electronically so that the various systems in a building can be programmed to make decisions based on inputs received from other systems. For example, data from an access control system can be integrated to a building’s HVAC system to turn the heat or cooling on whenever someone with the proper access level is granted access to a designated space. Presenting your access card at the optical turnstile could start your billing time at work and allow access to the company’s network. Failure to use your card at the turnstile would indicate to the system that you are not present in the building; therefore, attempts to access your computer would be denied. Companies with multiple facilities can integrate their systems so that once an employee is terminated, their access to all company facilities and services are revoked by either human resources or the security department with a simple keystroke.
The integration of various security systems into a single operating platform allows for better command and control for the operators. But, the huge gain is in the system’s ability to make decisions and communicate with each other, which can result in huge savings in operational costs to a building owner. For instance, cameras that produce usable video in poor- and no-light conditions can result in the elimination of outdoor light along a building perimeter. Cameras with infrared light need little or no background light to operate, whereas thermal-imaging cameras can operate in total darkness. Therefore, a facility with a large perimeter requiring camera coverage could see substantial savings if the cost of lighting along the perimeter is eliminated. For facilities that still need the option of lighting, operating costs can be reduced by having the intrusion detection system activate the light when the security system has been breached. Therefore, under normal operating conditions, the lights are off and will only be on when the intrusion detection system is activated. The ability to control light can be quite important to a building owner, especially in suburban and rural areas where maintaining bright lights continuously often results in complaints from surrounding neighbors.

Using a combination of card readers, intercoms, and CCTV systems accomplishes several things. Security personnel can command and control several sites from a single remote location while remaining safe and secure from immediate threats. Individuals with proper access do not require assistance for entry, and those in need of assistance can communicate their request through an intercom system that verifies their identity via CCTV cameras. Using a single command and control center means that all security-related incidents can be tracked, processed, and investigated from a single point.

Banks that have multiple locations can monitor each branch and/or automatic teller machines (ATMs) from a single monitoring center, enabling them to be proactive in their response to a variety of security- or fraud-related activities. A dispute over the use of a stolen ATM card or cashing of a check can easily be verified by playing back the recorded video from the location where the incident occurred. The ability to quickly pinpoint the location of a particular incident can result in a better response to law enforcement requests once an incident has been reported.

The days of lock and key have given way to sophisticated reading devices that scan cards from a distance, as well as measure distinct physical characteristics or personal traits of an individual’s biometrics. To access a highly secure space, one may find a combination of various reading devices that read fingerprints, facial characteristics, scans of the retina and iris, and analyzes voice patterns. These devices compare the biometric information presented to the information already on file. This information can be supplied by a database located on a company file server or within an individual’s “card” using a smart chip. Multiple layers of required authentication are quite secure when granting access - assuming the unlikely possibility of someone bringing your biometric data and card to a reader without your knowledge.

As the need increases to control and restrict access to facilities, the need to view and record entrances and exits of these buildings no longer rests with the human eye, but with camera systems and specialized software that can adapt to the environment and make decisions based on changes that may occur in the environment under surveillance. Intelligent video systems can alert security personnel if someone is approaching a fence area rather than moving away from it. Individuals with packages can be tracked and an alert can be sounded if they leave the package unattended. High-value items such as paintings can be placed under constant surveillance, and their removal can be programmed to trigger an alarm.
In a world where the threat level increases and decreases as a result of events beyond our control, the security ring must be designed with several layers of protection that can then be tailored to match the level of threat, whether real or perceived, on a real-time basis. Therefore, card readers that require a match of both card and biometric data before granting access to a building may be programmed to require only the programmed card under normal operating conditions, but require a match between the card and biometric data before granting access during times when the threat level has increased. Using this two-stage requirement can be quite effective and enables building occupants to be cognizant of the increased threat level in effect.

7.5 ELECTRICAL AND SPECIAL SYSTEMS CHECKLIST

**Electrical Systems:**

1. Are there any transformers or switchgear located outside the building or accessible from the building exterior? Are they vulnerable to public access? Are they secured?

Protection of the primary electrical service equipment is paramount to the building protection.

2. What is the extent of the external building lighting in utility and service areas and at normal entryways used by the building occupants?

The concern is to similarly protect critical components.

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?

The concern is to similarly protect critical components.

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.

5. How are electrical distribution panels serving branch circuits secured or are they in secure locations?

The concern is to similarly protect critical components.

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 initial concerns. Emergency and normal electrical equipment should be installed separately, at different locations, and as far apart as possible.
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.

**Life Safety Systems:**

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.

2. Where are the fire alarm panels located? Do they allow access to unauthorized personnel?

The concern is to similarly protect critical components.

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?

The concern is to similarly protect critical components.

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.

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.

6. 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.

7. Does the telephone system have an uninterruptible power supply (UPS)? What are its type, power rating, 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.

8. 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.

9. **How is the communications system wiring distributed (secure chases and risers, accessible public areas)?**

The intent is to prevent tampering with the systems.

10. **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.

11. **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.

12. **Is the building Local Area Network (LAN) used for emergency systems (HVAC, communications, fire alarm, etc.)? What type of 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:

   a. Bus (single radial where any damage on the bus affects the whole system, but especially all portions downstream)

   b. 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)

   c. 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.

13. **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.
14. 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.

15. 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?

Electronic Security:

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 is 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 should be considered for areas that lack adequate illumination for color cameras.

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.

3. What type of camera housings are used and are they environmental in design to protect against exposure to heat and cold weather elements?

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.
5. Are intercom call boxes used in parking areas or along the building perimeter?

Call boxes should be provided at key public contact areas and in garages and parking lots.

6. What is the transmission media used to transmit camera video signals: fiber, wire line, telephone wire, coaxial, wireless?

7. Who monitors the CCTV system?

8. What is the quality of video images both during the day and hours of darkness? Are infrared camera illuminators used?

9. Are the perimeter cameras supported by an uninterruptible power supply, battery, or building emergency power?

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.

11. What access control system equipment is used?

12. 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?

13. 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.

14. 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.
15. **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.

16. **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?

17. **Is the location of the security room in a secure area with limited, controlled, and restricted access controls in place?**

18. **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 (PDA's))?**