

NFPA 730

Guide for Premises Security

2006 Edition



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NFPA 730
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Premises Security
2006 Edition

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This edition of NFPA 730 was approved as an American National Standard on August 18, 2005.

Origin and Development of NFPA 730

The genesis of NFPA 730 was a request in 1994 to develop a burglary/security document. This project did not materialize until the year 2000, when the Standards Council appointed a committee to develop a premises security document. The committee responded by developing two documents, NFPA 731, *Standard for the Installation of Electronic Premises Security Systems*, and NFPA 730, *Guide for Premises Security*.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on the overall security program for the protection of premises, people, property, and information specific to a particular occupancy. The Committee shall have responsibility for the installation of premises security systems.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in advisory sections of this document are given in Chapter 2 and those for extracts in the informational sections are given in Annex C. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text should be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex C.

Chapter 1 Administration

1.1 Scope.

1.1.1 This guide describes construction, protection, occupancy features, and practices intended to reduce security vulnerabilities to life and property.

1.1.2 This guide is not intended to supersede government statutes or regulations.

1.2 Purpose. The purpose of this guide is to provide criteria for the selection of a security program to reduce security vulnerabilities.

1.2.1 The guide addresses other considerations that are essential for protection of occupants, in recognition of the fact that security is more than a matter of having a security system.

1.2.2 The guide also addresses protective features and systems, building services, operating features, maintenance activities, and other provisions, in recognition of the fact that achieving an acceptable degree of safety depends on additional safeguards to protect people and property exposed to security vulnerabilities.

1.3 Application. This guide applies to both new and existing buildings, structures, and premises and provides guidance for designing a security system for buildings or structures occupied or used in accordance with the individual facility chapters outlined in Chapters 11 through 22.

1.4 Equivalency. Nothing in this guide is intended to prevent the use of systems, methods, or devices of equivalent or superior

quality, strength, fire resistance, effectiveness, durability, and safety over those suggested by this guide.

1.5 Units and Formulas.

1.5.1 SI Units. Metric units of measurement in this guide are in accordance with the modernized metric system known as the International System of Units (SI).

1.5.2 Primary and Equivalent Values. If a value for a measurement as given in this guide is followed by an equivalent value in other units, the first stated value should be regarded as the requirement. A given equivalent value might be approximate.

1.5.3 Conversion Procedure. SI units have been converted by multiplying the quantity by the conversion factor and then rounding the result to the appropriate number of significant digits.

1.6 Title. NFPA 730, *Guide for Premises Security*, should be known as the “Premises Security Guide,” is cited as such, and is referred to herein as “this guide” or “the guide.”

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this guide and should be considered part of the recommendations of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 72®, *National Fire Alarm Code*®, 2002 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1999 edition.

NFPA 101®, *Life Safety Code*®, 2006 edition.

NFPA 731, *Standard for the Installation of Electronic Premises Security Systems*, 2006 edition.

2.3 Other Publications.

2.3.1 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM F 567, *Standard Practice for the Installation of Chain-Link Fence*, 2000.

ASTM F 1090, *Standard Classification for Bank and Mercantile Vault Construction*, 1992.

ASTM F 1233, *Standard Test Method for Security Glazing Materials and Systems*, 1995.

ASTM F 1247, *Standard Specification for Intrusion Resistant Generic Vault Structures*, 1996.

2.3.2 BMHA Publications. Builders Hardware Manufacturers Association, 355 Lexington Avenue, 17th floor, New York, NY 10017.

ANSI/BHMAA156.1, *Butts and Hinges*, 2000.

ANSI/BHMA A156.2, *American National Standard for Bored and Preassembled Locks and Latches*, 1996.

ANSI/BHMAA156.4, *Door Controls — Closers*, 2000.

ANSI/BHMAA156.5, *Auxiliary Locks and Associated Products*, 2001.

ANSI/BHMA A156.12, *Interconnected Locks and Latches*, 1999.

ANSI/BHMAA156.13, *Mortise Locks and Latches Series 1000*, 2002.

ANSI/BHMAA156.16, *Auxiliary Hardware*, 2002.

ANSI/BHMAA156.17, *Self-Closing Hinges and Pivots*, 2004.

ANSI/BHMAA156.23, *Electromagnetic Locks*, 2004.

ANSI/BHMAA156.24, *Delayed Egress Locking Systems*, 2003.

ANSI/BHMAA156.25, *Electrified Locking Devices*, 2002.

ANSI/BHMAA156.26, *Continuous Hinges*, 2000.

ANSI/BHMAA156.28, *Recommended Practice for Keying Systems*, 2000.

ANSI/BHMAA156.30, *High Security Cylinders*, 2003.

ANSI/BHMAA156.31, *Electric Strikes and Frame Mounted Actuators*, 2001.

2.3.3 IESNA Publications. Illuminating Engineering Society of North America, 120 Wall Street, Floor 17, New York, NY 10005.

Lighting Handbook, 8th edition, 1993.

RP-20, *Lighting for Parking Facilities*, 1998.

2.3.4 SDI Publications. Steel Door Institute, managed by Wherry Associates, 30200 Detroit Road, Cleveland, OH 44145-1967.

ANSI/SDI A250.4, *Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors and Hardware Reinforcing*, 2001.

ANSI/SDI A250.8, *Recommended Specifications for Standard Steel Door Frames*, 2003.

2.3.5 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 294, *Standard for Access Control System Units*, 1999, revised 2004.

UL 305, *Standard for Panic Hardware*, 1997, revised 2004.

UL 437, *Standard for Key Locks*, 2000, revised 2004.

UL 608, *Burglary Resistant Vault Doors and Modular Panels*, 2004.

UL 681, *Installation and Classification of Burglar and Holdup Alarm Systems*, 2001.

UL 687, *Burglary Resistant Safes*, 2000.

UL 752, *Standard for Bullet-Resisting Equipment*, 2000.

UL 768, *Standard for Combination Locks*, 1999.

UL 972, *Standard for Burglary Resisting Glazing Material*, 2002

UL 1034, *Standard for Burglary-Resistant Electric Locking Mechanisms*, 2000, revised 2004.

UL 2058, *High Security Electronic Locks*, 2005.

UL 3044, *Standard for Surveillance Closed Circuit Television Equipment*, 1998.

UL *Burglary Protection Equipment Directory*, <http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/index.htm>

UL *Security Equipment Directory*, <http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/index.htm>

2.3.6 U.S. Army Corps of Engineers Publication. U.S. Army Corps of Engineers, 10 South Harvard Street, Baltimore, MD 21201.

S/N 0-635-034/1069. "Physical Security." U.S. Army Field Manual 19-30, March 1979.

2.3.7 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

S/N 027-000-01362-7, U.S. Department of Justice. *Vulnerability Assessment of Federal Facilities*, 1995.

2.3.8 Other Publication. *Merriam-Webster's Collegiate Dictionary*, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Advisory Sections.

NFPA 72[®], *National Fire Alarm Code*[®], 2002 edition.

NFPA 99, *Standard for Health Care Facilities*, 2005 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter apply to the terms used in this guide. Where terms are not defined in this chapter or within another chapter, they should be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, is the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Guide. A document that is advisory or informative in nature and that contains only nonmandatory provisions. A guide may contain mandatory statements such as when a guide can be used, but the document as a whole is not suitable for adoption into law.

3.2.4 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.5* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.6 Shall. Indicates a mandatory requirement.

3.2.7 Should. Indicates a recommendation or that which is advised but not required.

3.3 General Definitions.

3.3.1* Access Control. The monitoring or control of traffic through portals of a protected area by identifying the requestor and approving entrance or exit.

3.3.2* Accessible Opening. An opening in a protected perimeter.

3.3.3 Alarm.

3.3.3.1* False Alarm. Notification of an alarm condition when no evidence of the event that the alarm signal was designed to report is found.

3.3.3.2* Holdup Alarm. An alarm that originates from a point where holdup protection is required, such as a bank teller window or store cash register.

3.3.3.3* Local Alarm. An alarm that annunciates at the protected premises.

3.3.4* Annunciator. A unit containing one or more indicator lamps, alphanumeric displays, computer monitor, or other equivalent means on which each indication provides status information about a circuit, condition, system, or location.

3.3.5 Area.

3.3.5.1* Controlled Area. A room, office, building, or facility to which access is monitored, limited, or controlled.

3.3.5.2 Protected Area. A protected premises or an area within a protected premises that is provided with means to prevent an unwanted event.

3.3.5.3* Restricted Area. A room, office, building, or facility to which access is strictly and tightly controlled.

3.3.6 Bar Lock. See 3.3.33.1.

3.3.7* Capacitance Sensor. A sensor that detects a change in capacitance when a person touches or comes in close proximity to an object.

3.3.8 Change Key. See 3.3.29.1.

3.3.9 Confidential Information. See 3.3.27.1.

3.3.10 Controlled Area. See 3.3.5.1.

3.3.11 Control Unit. A system component that monitors inputs and controls outputs through various types of circuits. [72, 2002]

3.3.12 Deterrent. Any physical or psychological device or method that discourages action.

3.3.13 Device.

3.3.13.1* Duress Alarm Device. An initiating device intended to enable a person at a protected premises to indicate a hostile situation.

3.3.13.2 Signaling Device. A device that indicates an alarm, emergency, or abnormal condition by means of audible or visual methods, or both.

3.3.14 Duress Alarm Device. See 3.3.13.1.

3.3.15 Duress Alarm System. See 3.3.45.1.

3.3.16 Electromagnetic Lock. See 3.3.33.2.

3.3.17 Expanded Metal. An open mesh formed by slitting and drawing sheet metal, made in various patterns and metal thicknesses, with either a flat or irregular surface.

3.3.18 False Alarm. See 3.3.3.1.

3.3.19* Foil. An electrically conductive ribbon used for a sensing circuit.

3.3.20 Grandmaster Key. See 3.3.29.2.

3.3.21 Health Care Facilities. Buildings or portions of buildings in which medical, dental, psychiatric, nursing, obstetrical, or surgical care are provided. [99, 2005]

3.3.22 Hinge Dowel. A dowel or pin that projects from a door jamb into an opening in the edge of a door at its hinge that prevents removal of the locked door even if the hinges or hinge pins are removed.

3.3.23 Holdup Alarm. See 3.3.3.2.

3.3.24 Holdup Alarm System. See 3.3.45.2

3.3.25 Human/Machine Interface (HMI). The point at which people control or monitor the condition of an electronic premises security system.

3.3.26* Identification Credential. A device or scheme containing some knowledge (personal identification number or code) or a biometric identifier.

3.3.27 Information.

3.3.27.1* Confidential Information. Information to which access is restricted.

3.3.27.2 National Security Information. Designated information that requires protection in the interest of national defense or foreign relations of the United States, that is, information classified in accordance with Executive Order 12356 and not falling within the definition of Restricted Data or Formerly Restricted Data.

3.3.28 Intrusion Detection System. See 3.3.45.3.

3.3.29 Key.

3.3.29.1 Change Key. A key that will operate only one lock or group of keyed-alike locks, as distinguished from a master key.

3.3.29.2 Grandmaster Key. The key that operates two or more separate groups of locks, each of which are operated by different master keys.

3.3.30 Keypad. A device that is a type of human/machine interface (HMI) with numerical or function keys that can incorporate an annunciator or signaling device.

3.3.31* Line Supervision. Automatic monitoring of circuits and other system components for the existence of defects or faults that interfere with receiving or transmitting an alarm.

3.3.32 Local Alarm. See 3.3.3.3.

3.3.33 Lock.

3.3.33.1* Bar Lock. (1) A type of rim lock in which metal bars slide out from a central point on the door and into receivers on both sides of the door frame. (2) A metal rod or tube that slides through fittings affixed to the front of a file cabinet, bent at the top and secured with a combination lock, which holds the drawers closed.

3.3.33.2* Electromagnetic Lock. A door lock that uses an electrically actuated magnetic attraction to secure the door.

3.3.34* Microwave Sensor. An active intrusion sensor that detects the movement of a person or object through a pattern of microwave energy.

3.3.35* Monitoring Station. A facility that receives signals and has personnel in attendance at all times to respond to these signals.

3.3.35.1* Central Station. A monitoring station that is listed.

3.3.35.2* Proprietary Station. A monitoring station under the same ownership as the property(ies) being monitored.

3.3.36 National Security Information. See 3.3.27.2.

3.3.37 Perimeter Protection. A scheme of protection that uses devices to detect intrusion at points of entry into a protected area such as doors, windows, and skylights.

3.3.38 Protected Area. See 3.3.5.2.

3.3.39* Reader. A device that allows an identification credential to be entered into an access control system.

3.3.40 Restricted Area. See 3.3.5.3.

3.3.41* Screens. An array of wires usually interwoven every six inches either horizontally or vertically on a screen or alarm screening that protects areas or openings, such as skylights and crawl spaces.

3.3.42 Signaling Device. See 3.3.13.2.

3.3.43 Supervised Lines. Interconnecting lines in an alarm system that are electrically supervised against tampering. See also 3.3.31, Line Supervision.

3.3.44 Surreptitious Entry. The unauthorized entry into a facility or security container in a manner such that evidence of the entry is not discernable under normal circumstances.

3.3.45 System.

3.3.45.1* Duress Alarm System. A system that controls duress alarm devices and operates in private or public.

3.3.45.2* Holdup Alarm System. A system or portion thereof in which the initiation of a holdup signal is either semiautomatic or manual.

3.3.45.3* Intrusion Detection System. A system designed to detect the entry or attempted entry of a person or vehicle into a protected area.

3.3.46 Top Guard. Antipersonnel device, usually of barbed or concertina wire, installed at the tops of fences and along roof edges.

3.3.47 Unauthorized Person. A person who does not have permission to enter a protected premises or is not authorized to have access to specific confidential information.

3.3.48 Vault. A windowless enclosure of heavy, reinforced construction with walls, floor, roof, and door(s) designed and constructed to delay penetration sufficiently to enable the timely arrival of response forces.

3.3.49 Zone. A defined area within a protected premises.

Chapter 4 General

4.1 Fundamental Recommendation. A security program should be based on a security vulnerability assessment as described in Chapter 5.

4.2 Classification of Facilities.

4.2.1 Facility Classification. The use of a building or structure, or portion of a building or structure, should be classified

in accordance with Chapters 11 through 21. Facility classification should be subject to the ruling of the authority having jurisdiction (AHJ) where there is a question of proper classification in any individual case.

4.2.2 Educational Facilities. Educational facilities include primary and secondary schools and colleges and universities.

4.2.3 Health Care Facilities. Health care facilities are used for purposes of medical service or other treatment simultaneously to four or more persons where one of the following conditions exist:

- (1) The occupants are mostly incapable of self-preservation due to age, physical or mental disability, or because of security measures not under the occupants' control.
- (2) The facility provides, on an outpatient basis, treatment for patients that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others.
- (3) The facility provides, on an outpatient basis, anesthesia that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others.

4.2.4 One- and Two-Family Dwellings. These are residential facilities containing one or two dwelling units that are occupied primarily on a permanent basis.

4.2.5 Lodging Facilities. The term *lodging facility* is an all-inclusive designation for facilities that provide housing and generally, but not always, food, beverage, meeting facilities, retail shops, recreational facilities, and other services. Hotels, motels, motor hotels, resort hotels, inns, country clubs, and conference centers are among the varieties of lodging facilities, and which term is applied is based primarily on differences in layouts and design.

4.2.6 Apartment Buildings. Apartment buildings generally are defined as buildings containing three or more dwelling units, each with independent cooking and bathroom facilities. They can also be referred to as apartment houses and garden apartments.

4.2.7 Restaurants. Restaurants include fast food establishments, convenience stores, walk-up-style facilities, and larger assembly-type facilities with full table service, lounges, and so forth.

4.2.8 Shopping Centers. A shopping center is a group of retail and other commercial establishments that is planned, developed, and managed as a single property.

4.2.9 Retail Establishments. Retail establishments are primarily engaged in the direct sale of goods and products to consumers.

4.2.10 Office Buildings. An office building is a facility used for office, professional, or service-type transactions, including but not limited to storage of records and accounts.

4.2.11 Industrial Facilities. An industrial facility is a facility in which products are manufactured or in which processing, assembling, mixing, packaging, finishing, decorating, or repair operations are conducted.

4.2.12 Parking Facilities. A parking facility is a structure or space where the primary use is storage of vehicles.

4.2.13 Mixed Facilities. A mixed facility is a facility in which two or more classes of facility exist in the same building or structure and where such classes are intermingled so that separate safeguards are impracticable.

4.3 System Design and Installation. Any security system, building service equipment, feature of protection, or safeguard provided for security should be designed, installed, and approved in accordance with applicable NFPA codes and standards, the manufacturer's specifications, applicable UL standards, the AHJ, and nationally recognized industry standards and practices.

4.4 Maintenance. Whenever or wherever any device, equipment, system, condition, arrangement, level of protection, or any other feature is recommended by this guide, such device, equipment, system, condition, arrangement, level of protection, or other feature should thereafter be maintained unless the guide exempts such maintenance.

Chapter 5 Security Vulnerability Assessment

5.1 General.

5.1.1* Security planning should begin with a security vulnerability assessment (SVA), which is a systematic and methodical process for the following:

- (1) Examining ways an adversary might exploit an organization's security vulnerabilities to produce an undesired outcome
- (2) Developing countermeasures to address adversarial events

5.1.2 An SVA is a technique for assessing the current status of an organization's threat exposures, security features and preparedness and can be used in developing and strengthening both security and safety layers of protection.

5.2 Application. A security vulnerability assessment usually involves a seven-step process.

5.2.1 Step 1: Formation of Team. The process should begin with the formation of a team of personnel from all organizational areas. Commonly, the individual responsible for an organization's security serves as team leader.

5.2.2 Step 2: Organization/Facility Characterization. Step 2 involves a characterization of an organization and the facilities to be protected. It includes identification of assets (i.e., people, property, information and products); physical features and operations; laws, regulations, and corporate policies; social and political environment and internal activity (i.e., community resources, crime statistics, internal activities, and loss experience); and review of "current layers of protection" (including both site security features and safety measures).

5.2.3 Step 3: Threat Assessment. The next step is conducting a threat assessment. The process includes a classification of critical assets, identification of potential targets, consequence analysis (effect of loss, including any potential off-site consequence), and the definition of potential threats (by identifying potential adversaries and what is known about them).

5.2.4 Step 4: Threat Vulnerability Analysis. The next step is conducting a threat vulnerability analysis that identifies actual and potential threat scenarios and estimates a relative security risk level. The relative security risk level is a function of determining the severity of the consequences of an adversarial event, the potential for such an attack, and the likelihood of adversary success in carrying out the anticipated event or activity.

5.2.5* Step 5: Define Specific Security Countermeasures. In this step, specific security countermeasures are defined. All

information from the previous four steps, including characterization, threat, and vulnerability analysis, is considered. An effective countermeasure is one that drives improvements in mitigating the defined threats and results in a reduction in the security risk level.

5.2.6 Step 6: Assess Risk Reduction. Taking into account the countermeasures defined in Step 5, reassess the relative security risk levels developed in Step 4 and consider additional security risk reduction measures (security countermeasures) where appropriate.

5.2.7 Step 7: Document Findings and Track Implementation. Document findings and recommendations in a report and track the implementation of accepted recommendations.

Chapter 6 Exterior Security Devices and Systems

6.1 General. This chapter covers the application of exterior security devices and systems.

6.2 Application. Exterior security devices and systems can be used in providing perimeter protection to a facility.

6.3 Exterior Security Devices and Systems.

6.3.1 Exterior security devices and systems include fences and other physical barriers, protective lighting, ironwork (e.g., bars and grills), glazing materials, passive barriers, and electronic security devices. Depending on their construction, walls, floors, roofs, doors, and windows can also be considered exterior security devices and systems. Compliance with applicable fire and building code requirements in any occupancy should be taken into consideration when any physical barriers are utilized or installed.

6.3.2 Perimeter protection defines the physical limits of a property, which can be the exterior boundaries of a premises or the walls, floor, and ceiling of a building.

6.4 Physical Barriers. Physical barriers can be of two general types — natural and structural. Natural barriers include mountains, cliffs, canyons, rivers, or other terrain that is difficult to traverse. Structural barriers are man-made devices, such as fences, walls, floors, and roofs. Fences are the most common perimeter barrier. Chain-link fencing is the most popular type of fence in use today, since it is simple to install, relatively inexpensive, and low in maintenance costs.

6.4.1 Application of Chain-Link Fencing. Chain-link fencing can be used in almost any application where there is a need for defining the physical boundaries of a facility or for a perimeter barrier that serves a security function. It is available in a variety of heights and materials and is installed to various specifications. To be most effective, a chain-link fence should be designed and installed to nationally recognized standards. The standards for the manufacture, design, and installation of chain-link fencing are published by the American Society for Testing and Materials (ASTM). ASTM F 567 provides materials specifications, design requirements, and installation procedures for chain-link fencing.

6.4.2 Design of Chain-Link Fencing. A chain-link fence consists of posts, braces, rails or tension wires, fabric, the fence top, and entrances. All materials used in the construction of the fence should be zinc-coated, aluminum-coated, or polyvinyl chloride-coated to afford protection from the elements. Subsection 6.4.3 describes important factors to be considered

in the construction, design, and installation of a chain-link fence, based on ASTM F 567 requirements.

6.4.3 The Fence Line. The fence line should be as straight as possible to provide for ease of observation. Clear zones should be provided on both sides of the fence to provide an unobstructed view. If practical, the fence should be located no closer than 50 ft (15.2 m) to buildings or outside storage areas, and 20 ft (6.1 m) to other areas, such as parking areas, which could afford concealment for an intruder. Utility poles in close proximity to the fence should be provided with a “security collar,” a device that prevents climbing the pole to a height greater than that of the fence.

6.4.3.1 Signs. “No Trespassing” or “Private Property” signs should be securely attached to the fence fabric. These signs should be placed at various points along the fence line to avoid accidental or inadvertent trespass by an intruder.

6.4.3.2 Height. Chain-link fences are available in heights ranging from 4 ft (1.2 m) for residential application to 12 ft (3.7 m) or more for use in prison facilities. In industrial or commercial security applications, the minimum recommended height for a chain-link fence is 8 ft (5.5 m), including 7 ft (2.1 m) of fabric (the chain-link material) and a top guard (discussed in 6.4.3.6) of approximately 1 ft (0.3 m). However, some fence manufacturers recommend that the fence height be 9 ft (2.7 m), since at this height the top of the fence is out of standing reach of most intruders.

6.4.3.3 Posts. The posts for a chain-link fence include terminal (end, corner, and gate) posts and line posts. For a fence with 7 ft (2.1 m) high fabric, the posts should be set in concrete at a minimum depth of 36 in. (0.9 m) and the surface of the concrete crowned to shed water. The posts should be set an additional 3 in. (76 mm) deeper for each 1 ft (0.3 m) increase in the height of the fence. The diameter of the hole for a terminal post should be at least 12 in. (305 mm) and for a line post, 9 in. (229 mm). Other installation methods are acceptable if they provide equivalent or superior strength to that developed using concrete footings. Line posts should be spaced equidistant at intervals not exceeding 10 ft (3.0 m), measured from center to center between terminal posts. End posts should be set within 2 in. (5.1 cm) of building walls.

6.4.3.4 Bracing. Terminal posts should be braced to each adjacent line post. Diagonal braces should be securely fastened to the terminal post and the line post, or its footing, so that the angle between the brace and the ground at the line post is no more than 50 degrees. When a top rail (discussed in 6.4.3.5.1) is used, the brace is attached at the halfway point of the terminal post; when the top rail is omitted, the brace is attached at the two-thirds point above grade. For horizontal bracing, the braces, with truss rods, are securely fastened at mid-height of the adjacent line posts and terminal post.

6.4.3.5 Rails and Tension Wires.

6.4.3.5.1 A top rail or top tension wire should be provided as support for the fence fabric. The top rail should be supported at each line post, so that a continuous brace from end to end of each stretch of fence is formed, and should be securely fastened to each terminal post. The top rail, usually in 18 ft (5.5 m) lengths, is joined with connectors that allow for expansion and contraction. On fences 12 ft (3.7 m) and more in height, a center rail is necessary.

6.4.3.5.2 A top rail improves the appearance of the fence, but also provides a handhold for someone attempting to climb

over the fence. For this reason, it is usually recommended that the top rail be omitted and replaced with a top tension wire. The top tension wire should be stretched taut, free of sag, from end to end of each stretch of fence, at a height within 1 ft (0.3 m) of the top of the fabric, and be securely attached to the terminal posts. A bottom tension wire that is within the bottom 6 in. (15.2 cm) of the fabric should also be provided. Some fences have a bottom rail in place of the bottom tension wire.

6.4.3.6 Fabric. The fabric for a chain-link fence should be steel wire, No. 9 gauge or heavier. The wire is interwoven in a diamond shaped pattern to form a continuous mesh without knots or ties except in the form of twisting or knuckling of the ends of the wire to form the selvage of the fabric. The mesh openings should not be larger than 2 in. (5.1 cm) per side.

6.4.3.6.1 Twisting describes the type of selvage obtained by twisting adjacent pairs of wire ends together in a closed helix of three full twists and cutting the wire ends at an angle to provide sharp points. The wire ends beyond the twist should be at least ¼ in. (0.6 cm) long. Knuckling describes the type of selvage obtained by interlocking adjacent pairs of wire ends and then bending the wire ends back into a closed loop.

6.4.3.6.2 In a commercial or industrial security application, the fabric should have twisted selvage at the top and, for safety reasons, it is usually recommended that the bottom selvage be knuckled. On fences less than 6 ft (1.8 m) in height, and in residential applications, both the top and bottom selvages should be knuckled, also for safety reasons.

6.4.3.6.3 The fabric should be stretched taut and securely fastened to the posts at 15 in. (38.1 cm) intervals. The top edge of the fabric should be fastened to the top rail or top tension wire at intervals not exceeding 24 in. (61 cm), and the bottom edge of the wire to the bottom rail or bottom tension wire at intervals not exceeding 24 in. (61 cm).

6.4.3.6.4 The bottom of the fabric should extend to within 2 in. (5.1 cm) of hard ground or paving. On soft ground, the fabric should extend below the surface of the soil or U-shaped stakes, approximately 2 ft (0.6 m) in length, can be driven into the ground to secure the fabric. Culverts, troughs, or other openings that are larger than 96 in.² (0.06 m²) in area should be protected by fencing or iron grills to prevent unauthorized entry while allowing for proper drainage.

6.4.3.7 The Top Guard. The top of the fence, including all entrances, should be provided with a top guard, or overhang, to deter attempts at climbing the fence. A top guard consists of three strands of No. 12 gauge barbed wire that are securely fastened to metal supporting arms, usually 18 in. (45.7 cm) in length, attached to the fence posts either vertically or at an angle of approximately 45 degrees.

6.4.3.7.1 When the top guard is angled, the arms, or outriggers, should be of sufficient strength to withstand a weight of 250 lb (113.4 kg) applied at the outer strand of barbed wire. The top strand of barbed wire should be at a height 12 in. (30.5 cm) vertically above the top of the fabric, with the other wires spaced uniformly along the arm.

6.4.3.7.2 The top guard can be installed facing either inward or outward from the fence line. It is usually recommended that the top guard face outward, since it is believed that this configuration makes it more difficult for an intruder to climb over the fence from the outside. If the fence is on the property line of the facility, however, the top guard should be installed facing inward; otherwise, it will extend over the property of

the adjoining neighbor or over public streets or highways. Some fences have a double overhang, in the shape of a vee (or “v”), making it more difficult to climb the fence from either side.

6.4.3.7.3 Barbed wire made of spring steel can be formed into concertina coils and used in place of the top guard for protecting the top of the fence. Because of the coiled configuration, concertina does not require supporting arms, and is usually attached to the top of the fence with wire ties and clamps.

6.4.3.7.4 Another material used to protect the top of a chain-link fence is barbed tape, also referred to as razor ribbon. Barbed tape is manufactured of stainless steel, 0.025 in. (0.6 cm) thick and 1 in. (2.54 cm) or 1¼ in. (3.2 cm) wide, with needle-sharp barbs that are spaced on 4 in. (10.2 cm) centers. Barbed tape should be securely fastened to the top of the fence and to a top wire that is stretched taut between vertical extensions on the line and terminal posts. Manufacturers of barbed tape recommend that the material be used on fences having a minimum height of 7 ft (2.1 m) so as to avoid the possibility of contact with pedestrian traffic. Barbed tape should never be used at heights below 7 ft (2.1 m).

6.4.4 Entrances. The number of entrances should be kept to a minimum, consistent with safe and efficient operation of the facility. Entrances can be designed for vehicular traffic or for pedestrians and are usually closed by a gate or turnstile.

6.4.4.1 Gates can be single- and double-swing for walkways, multifold for wide entrances, double-swing and overhead single- and double-sliding for driveways, cantilever single- and double-sliding for driveways where an overhead track would be in the way, or vertical-lift for special purposes such as load-in docks. Any of these gates can be motor operated.

6.4.4.2 The frames for gates should be constructed of tubular members that have been welded together at the corners or assembled with fittings and should be provided with truss rods or braces, as required, to prevent sagging or twisting. The fabric should be the same as that used for the fence and should be fastened to the gate frame at 15 in. (38.1 cm) intervals. The gate should be mounted so that it cannot be lifted off its hinges. The bottom of the gate should be within 2 in. (5.1 cm) of the ground.

6.4.4.3 Turnstiles are utilized in fences for the control of pedestrian traffic and are available in either of two heights. Waist-height turnstiles are about 36 in. (91.4 cm) high and usually are used to count the number of personnel going through an access point; they do not provide any degree of security unless constantly attended. Full-height turnstiles, which are usually about 7 ft (2.1 m) high, completely surround individuals as they pass through. Full-height turnstiles do function as security barriers, since they can be locked to prevent access or automated through the use of an access control system.

6.4.4.4 When entrances are not staffed, they can be securely locked, illuminated during the hours of darkness, and periodically inspected. Semi-active entrances, such as railroad siding gates, or gates used only during peak traffic flow periods, can be kept locked except when actually in use.

6.4.5 Locks.

6.4.5.1 Locks are essential parts of fences and the protection they provide. Gates are usually locked by means of a padlock. Padlocks can be key- or combination-operated, with a key-operated padlock the preferred type. The padlock should have a shrouded shackle, to resist sawing, and bolt cutters and should lock on both sides of the shackle (heel-and-toe lock-

ing). The padlock should be installed so that it cannot be easily attacked from the street side with a hammer.

6.4.5.2 If a chain and padlock are used to secure the gate, the chain, as a minimum, should be case-hardened. If possible, the chain should be installed so that the lock is on the inside of the gate when the gate is closed. The keys to the padlocks should be strictly controlled.

6.4.6 Lighting. Lighting should be provided along the fence line and at all entrances to enhance visibility and deter intrusion.

6.4.6.1 Table 6.4.6.1 provides minimum lighting levels that can be used for fences.

Table 6.4.6.1 Recommended Minimum Illumination Levels for Fencing

Location	Footcandles (on horizontal plane at ground level)
Perimeter of outer area	0.15
Perimeter of restricted area	0.4
Vehicular entrances	1.0
Pedestrian entrances	2.0
Entrances (inactive)	0.1

Source: U.S. Army Field Manual 19-30, 1979.

6.4.6.2 Information on recommended lighting levels for fences, including entrances, is also provided in the *Lighting Handbook*, 9th ed., published by the Illuminating Engineering Society of North America (IESNA).

6.4.7 Maintenance.

6.4.7.1 The area on either side of the fence should be kept clear of trees, shrubbery, and tall grass that could afford concealment for an intruder. Items that might assist an intruder in climbing over the fence, such as boxes, containers, vehicles, and equipment, should be located away from the fence.

6.4.7.2 To be most effective, the fence should be well maintained. Breaks or damage to the fence should be repaired promptly. The fence should be inspected on a regular basis to check for any cuts or openings that can be camouflaged.

6.5 Protective Lighting. Protective lighting is a valuable and inexpensive deterrent to crime. It improves visibility for checking badges and people at entrances, inspecting vehicles, preventing illegal entry, and detecting intruders both outside and inside buildings and grounds.

6.5.1 Lighting Terms.

6.5.1.1 *Luminous flux* refers to the gross amount of light generated by a source, irrespective of the intensity of the light in a given direction. The unit of luminous flux is the *lumen* (lm).

6.5.1.2 *Luminous intensity* is the luminous flux per unit solid angle in the direction in which the flux is emitted. The unit of luminous intensity is the *candela* (cd). At one time, candela was called candle or candlepower.

6.5.1.3 *Illuminance* is the density of incident luminous flux on a surface. Illuminance is the standard measure for lighting levels and is measured in *footcandles* (fc) (1 lm/ft²) or *lux* (lx) (1 lm/m²).

6.5.1.4 Luminance. This relates to the luminous intensity of a surface in a given direction per unit area of that surface as viewed from that direction and is often incorrectly referred to as “brightness.” The unit of luminance is the candela per square meter (cd/m^2).

6.5.2 Principles of Protective Lighting. Protective lighting should attempt to accomplish the objectives in 6.5.2.1 through 6.5.2.9.

6.5.2.1 Illumination of all exterior areas in a facility, including pedestrian and vehicular entrances, the perimeter fence line, sensitive areas or structures within the perimeter, and parking areas, should be provided in accordance with the recommendations of Table 6.5.2.1.

Table 6.5.2.1 Recommended Minimum Intensities for Outdoor Protective Lighting

Location	Footcandles (on horizontal plane at ground level)
Perimeter of outer area	0.15
Perimeter of restricted area	0.4
Vehicular entrances	1.0
Pedestrian entrances	2.0
Sensitive inner areas	0.15
Sensitive inner structures	1.0
Entrances (inactive)	0.1
Open yards	0.2
Docks/piers	1.0

Source: U.S. Army Field Manual 19-30, 1979.

6.5.2.1.1 Information on recommended lighting levels for outdoor protective lighting is also provided in the *Lighting Handbook*, 9th ed., published by the Illuminating Engineering Society of North America (IESNA).

6.5.2.2 Intruders should be discouraged or deterred from attempts at entry by making detection certain. Proper illumination can lead a potential intruder to believe detection is inevitable.

6.5.2.3 A glare that handicaps guards and annoys passing traffic and occupants of adjacent properties should be avoided.

6.5.2.4 The glare should be directed at intruders, where appropriate, as a means of handicapping them.

6.5.2.5 Guard posts and video surveillance cameras should be in low-light locations to render their positions harder for the intruder to pinpoint.

6.5.2.6 Redundancy should be provided so that a single lamp outage does not result in a dark spot vulnerable to intrusion.

6.5.2.7 Complete reliability should be provided such that, in the event of a power failure, standby illumination is available.

6.5.2.8 Protective lighting should be resistant to vandalism and sabotage. Fixtures should be installed high, out of reach of potential intruders and be of the vandal-resistant type.

6.5.2.9 Protective lighting should be covered under a maintenance agreement such that repairs are made in a timely fashion.

6.5.3 Types of Light Sources. Electric lamps are the principal source of light in common use. They convert electrical energy

into light or radiant energy and are classified into three categories: incandescent, fluorescent, and high-intensity discharge.

6.5.3.1 Incandescent Lamps.

6.5.3.1.1 In an incandescent lamp, current is run through a wire or filament that heats up and glows (incandesces), giving off light. The filament, usually of tungsten, is enclosed in a glass tube that contains a specialized atmosphere, usually of argon and nitrogen, that prevents oxidation of the filament at elevated temperatures. Compared to other light sources, incandescent lamps have a low initial cost, a relatively short life (500 hours to 4000 hours), and low efficiency in lumens per watt (17 LPW to 22 LPW) of electrical energy; however, they give a generally pleasant color rendition, are easy to dim, and are readily controlled.

6.5.3.1.2 Included in the category of incandescent lamps is the tungsten halogen (or quartz iodide) lamp. Tungsten halogen lamps improve the rate of depreciation of the light output of a standard incandescent lamp, called lamp lumen depreciation, by enclosing the tungsten filament in a quartz tube containing a halogen gas. This design deters tungsten particles from depositing on the bulb wall, as is common with incandescent lamps and which causes blackening of the bulb. The design helps these particles re-deposit on the filament, increasing lamp life. Efficiency and color rendition of tungsten halogen and standard incandescent lamps are approximately the same.

6.5.3.2 Fluorescent Lamps. The fluorescent lamp produces light when an electrical discharge generates ultraviolet energy that activates fluorescent powders on the walls of a glass tube. A choice of phosphors used in the fluorescent lamp allows for the manufacture of lamps with different color characteristics. To operate, a fluorescent lamp requires auxiliary equipment, called a ballast, that acts as a current-limiting device and provides the voltage necessary to insure ignition of the arc. Fluorescent lamps provide good color rendition, high lamp efficiency (67 LPW to 100 LPW), and life (9,000 hours to 17,000 hours). They are temperature sensitive, with low ambient temperatures decreasing their effectiveness. Fluorescent lamps cannot project light over long distances and so are not desirable as floodlights.

6.5.3.3 High-Intensity Discharge (HID) Lamps. High intensity discharge lamps include mercury vapor, metal halide, and high-pressure sodium.

6.5.3.3.1 Mercury Vapor Lamps. These were the first of the HID lamps to be developed. Light is produced by the passage of an electric current through mercury vapor. These lamps are constructed of an inner quartz arc tubing containing an electrode at either end. The tube contains an electrode that starts the mercury vapor oxidation process necessary for ignition. The entire assembly is covered by an outer glass shell. As with fluorescent lamps, a ballast is necessary to limit the current and provide the required voltage. Mercury vapor lamps are known for their long life (24,000+ hours) and good efficiency (31 LPW to 63 LPW) compared to incandescent lamps. Phosphor-coated lamps provide good color rendering similar to that of cool white fluorescent lamps. Because of their long life, mercury vapor lamps are widely used in street lighting; approximately 75 percent of all street lighting is mercury vapor.

6.5.3.3.2 Metal Halide Lamps. These are similar in design and operation to mercury vapor lamps; however, they use metal halides in addition to the mercury to produce better color rendition. Metal halide lamps have an efficiency (80 LPW

to 115 LPW) approximately 50 percent higher than mercury vapor lamps, but have a much shorter lamp life (6000 hours). They are used where efficiency, color, and light control are most important.

6.5.3.3.3 High-Pressure Sodium (HPS) Lamps. HPS lamps were introduced in 1965. They have rapidly gained acceptance for the exterior lighting of parking areas, roadways, and building exteriors because of their high efficiency. Operating on the same principles as mercury vapor and metal halide lamps, HPS lamps contain xenon as a starting gas to initiate the arc that vaporizes a sodium-mercury amalgam; however, they differ in construction and physical appearance. HPS lamps have a high lumen efficiency (80 LPW to 140 LPW), relatively good color rendition, long lamp life (24,000 hours), and an excellent lumen depreciation factor that averages about 90 percent throughout its rated life. HPS lamps are used where efficiency is most important.

6.5.4 Warm-Up and Restrike Times. Table 6.5.4 provides information on the time required for the lighting sources discussed to achieve full illumination. Initial warm-up is the time in minutes from initial starting to full light output at room temperature. Restrike time is the cooling time required before the lamp will restart. During the initial warm-up and restrike periods, a lamp will not operate at full output, which can be an important consideration in some security applications. The ranges given are a function of lamp wattage, with higher wattages requiring longer warm-up and restrike times.

Table 6.5.4 Time Required in Minutes to Reach Full Illumination for Various Lighting Sources

Lighting Source	Initial Warm-Up	Restrike Time
Incandescent	0	0
Tungsten halogen	0	0
Fluorescent	0	0
Mercury (clear)	5–7	3–6
Mercury (phosphor)	5–7	5–7
Metal halide	3–5	10–15
High pressure sodium	3–4	1

6.5.5 Types of Luminaires. A luminaire is a complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply. A wide range of luminaires is available for protective lighting. Of these, there are four general types that are most often used in a protective lighting system: floodlights, street lights, Fresnel lens units, and search lights. The type best suited to a particular application is based on the patterns of light distribution desired and the convenience of servicing, since the cost of maintenance affects the overall suitability of a protective lighting system.

6.5.5.1 Floodlight Luminaires.

6.5.5.1.1 Application. Floodlights are designed to form the light into a beam so that it can be projected to distant points or to illuminate definite areas. Floodlights are used for the illumination of boundaries, fences, buildings, and for local emphasis of vital areas or buildings.

6.5.5.1.2 Reflectorized Lamps. Floodlights with reflectorized lamps, which are lamps with a reflecting coating applied directly to part of the bulb surface, are applicable for lighting small areas and irregular spaces, such as around building setbacks, stockpiles of materials and tanks, and for boundary lighting where the light must be confined to the immediate fence area.

6.5.5.1.3 Floodlight Specifications. Floodlights are specified in wattage and beam spread. Beam spreads, expressed in degrees, define the angle included within a beam. The greater the distance from the floodlight to the area to be protected, the narrower is the beam spread desired. Since the illumination at the edge of a floodlight beam is significantly less than that at the center (about one-tenth), the beams of individual floodlights must be overlapped to obtain the desired illumination.

6.5.5.1.4 Classification. Outdoor floodlights are classified according to beam spread by the National Electrical Manufacturers' Association (NEMA) as to Types 1 through 7; they are also referred to by the terms narrow, medium, and wide. They are available for use with different types and sizes of lamps, both incandescent and HID, and can be either open or closed, the latter being equipped with a glass cover to exclude rain, dust and other airborne contaminants.

6.5.5.2 Street Light Luminaires.

6.5.5.2.1 Classification. Street lights are rated by the size of the lamp the fixture accommodates and the characteristics of the light distribution. They are classified as Types I thru V. The distribution of the light can be symmetrical or asymmetrical.

6.5.5.2.2 Symmetrical Distribution. Street light luminaires with symmetrical distributions find application in lighting large areas where the luminaires can be located centrally with respect to the area to be lighted. They can also be used at entrances and exits and for special boundary conditions.

6.5.5.2.3 Asymmetrical Distribution. Street light luminaires with asymmetrical distribution direct light by reflection, refraction, or both into the area to be lighted. They find application where the location and position of the lighting unit is restricted with respect to the area to be lighted. An example of asymmetrical distribution is the illumination of boundaries where the fixture is located inside the property and the light is delivered largely outside the fence. Another example is a roadway where the fixture must be placed outside the limits of the roadway but the effective light is that reaching the road surface.

6.5.5.3 Fresnel Lens Luminaires. Fresnel lens units used in protective lighting systems deliver a fan-shaped beam of light approximately 180 degrees in the horizontal and 15 degrees to 30 degrees in the vertical. They are intended to protect a property by directing the light outward to illuminate the approaches and inflict glare on the would-be intruder, while affording a guard comparative concealment in darkness. The use of Fresnel lens units is usually limited to facilities where the resulting glare will not be objectionable, such as commercial and industrial facilities that do not border on residential areas.

6.5.5.4 Search Light Luminaires. Search lights usually are incandescent, since incandescent lamps reach full brilliance immediately and permit very concentrated beam distributions. Search lights are generally used to supplement the fixed lighting at a location. The mountings for search lights are usually of the ped-

estal type, since these place the controls in the hands of guards. Portable, battery-powered search lights are also available. Search lights are generally rated by the diameter of the reflector, which can range from 12 in. to 24 in., and the wattage of the lamp, which can range from 250 watts to 3000 watts.

6.6 Walls, Floors, and Ceilings. In most commercial burglaries, the point of attack is a door, window, or other accessible opening. However, if these openings are secure, a burglar will try to penetrate exterior walls, especially if high-value items are inside the structure. Wood frame and masonry or concrete are the basic materials used in most commercial wall construction.

6.6.1 Walls. Wood frame walls are relatively inexpensive, easy to build, durable, and provide good insulation against noise, weather, and heat loss; but they do not provide much penetration resistance. A determined intruder can usually break through an ordinary frame structure in just a few minutes, making a frame wall insufficient protection for high-value property, unless coupled with an intrusion detection system or other physical safeguards.

6.6.1.1 Masonry and concrete walls are more expensive than frame walls and are used in commercial structures because of their durability, resistance to fire, and insulation against weather, noise, and heat loss. They usually consist of either poured concrete or concrete block and can have a layer of brick face.

6.6.1.2 Poured concrete walls are relatively difficult to penetrate. Concrete block walls that have not been filled with concrete or reinforced with steel can be as vulnerable to attack as wood frame walls. Ultimately, any masonry wall can be penetrated by a determined attack.

6.6.2 Roofs.

6.6.2.1 Sloping roofs (of whatever style) are unattractive to intruders because anyone on a sloping roof is usually visible from ground level. The slope itself poses a risk of falling, and the necessary tools must be held in place while not being used. However, sloping roofs should be analyzed with respect to ventilating ducts, skylights, or other possible access points.

6.6.2.2 The flat roofs most often found on commercial buildings can, on the other hand, be very attractive to intruders. Because the walls on many commercial buildings extend a few feet above the roof line, they can provide excellent concealment for any intruder attempting to penetrate the roof. Large, sophisticated tools can be used for an extended period of time, and a considerable amount of noise can be made if the building is unoccupied. Given such favorable conditions, flat roofs, except ones made of reinforced concrete, can be attractive attack points for burglars.

6.6.2.3 Penetration of the roof itself is seldom required, however, because the typical flat commercial roof offers numerous skylights, ventilation openings, elevator access doors, trap doors, and other maintenance access ways that are more convenient points of entry. Such access points can and should be strengthened to the point that they are as resistant to penetration as the roof itself. Intrusion detection systems should also be considered in these areas.

6.6.3 Accessible Openings. As noted in Section 6.6, doors and windows are the preferred entry points for burglars. As such, all doors and windows and other openings that are accessible should be protected.

6.6.3.1 Most doors and windows are considered accessible. Roofs are often overlooked, but openings such as vents, skylights, and maintenance access ways may also be considered accessible.

6.6.3.2 A burglar can either attempt to go through the door or window, such as by breaking out a panel, or attempt to pry open the door or window. These types of attacks can be prevented through the use of security devices such as locks and ironwork.

6.6.3.3 Some consideration should be given to the construction of the walls that support the doors or windows since they impact the security provided by doors and windows. Concrete and masonry walls provide rigid support for door frames when the frames are properly mounted. Wood frame construction, on the other hand, is usually flexible enough to allow a burglar to spread the door frame even when it is solidly fastened to the structure.

6.6.3.4 Windows are a particularly difficult problem in building security. Their primary functions are to provide light, ventilation if they can be opened, and to serve as a barrier to the elements. They are not ordinarily intended to serve as a security barrier, and improving their security using ironwork and burglary resistant glazing materials is normally difficult without impacting their primary function or creating a life safety hazard.

6.7 Ironwork. Ironwork, such as crossbars, gates, and screens, are used on doors and windows to protect against unauthorized intrusion.

6.7.1 Crossbars.

6.7.1.1 Crossbars, or braces of steel, are horizontal bars used on secondary exterior doors and shutters (of wood and/or metal) in mercantile establishments. They provide additional rigidity to the door or shutter to limit their potential for being smashed or rammed open. Crossbars afford good security if they fit tightly in their brackets and have padlocks or other means to prevent their easy removal.

6.7.1.2 A steel crossbar should have cross sectional dimensions of at least 1¼ in. × ½ in. (4.4 cm × 1.3 cm). The bracket should be of comparable strength as the bar and should be securely bolted to the door or wall. To prevent the bar from being sawed through or lifted out of the bracket from the outside, the space between the door and frame, or between double doors, should be covered with an overlapping metal plate.

6.7.2 Flat or Round Iron Bars.

6.7.2.1 Iron bars (the term *iron* is used here in the vernacular) are used to protect windows, transoms, skylights and vents. Round bars should be at least ¾ in. (1.9 cm) diameter, while flat bars are usually 1½ in. × ¾ in. (3.8 cm × 1 cm). Round bars can be mortised in masonry, fashioned in a frame, or designed with horizontal crossbars for added strength and support. Vertical bars should be spaced not more than 5 in. (12.7 cm) apart and horizontal bars 24 in. (61 cm) or less.

6.7.2.2 Bars should be secured to the window frame with heavy lag bolts that have been welded over, or by bolts and nuts that have been peened, to prevent their easy removal. For a hinged installation, provision must be made to prevent removal of the hinge pins or attack on the lock.

6.7.2.3 It is always preferred that ironwork be installed on the inside of the premises, behind the door or window. Exterior installations are susceptible to being pried, pulled off, or otherwise attacked. With inside installations, however, the intruder would have to break the glass or cut through the door, thereby making noise, before getting to the substantial security, the ironwork.

6.7.2.4 Iron gates are used as security devices on entrances to stores and mercantile occupancies. Round bars should be at least $1\frac{1}{2}$ in. (1.3 cm) diameter, while flat bars should be at least $1\frac{1}{2}$ in. $\times$ $\frac{3}{8}$ in. (3.8 cm $\times$ 1 cm); vertical bars should be spaced not more than 5 in. (12.7 cm) apart. The lock used to secure the gate should be of the deadbolt type with a minimum bolt throw of 1 in. (2.5 cm), and protected so that it cannot be reached from outside of the gate. The gate frame should be securely anchored within the opening to prevent the frame from being pried off, and the gate should be provided with an overlapping metal trim along its edge to cover the gap between the gate and frame. If the hinge pin is removable, then provision should be made to secure it.

6.7.3 No. 18 Gauge Sheet Steel Panel.

6.7.3.1 Exterior wood doors, especially hollow-core and wood panel doors, are vulnerable to entry attempts to cut or chop a hole through the door to gain access to the lock or the premises. These doors can be reinforced by the installation of a No. 18 gauge or thicker sheet steel panel.

6.7.3.2 The panel should be attached to the inside surface of the door, covering its length and width, with screws on maximum 6 in. (15.2 cm) centers. Since the panel will add extra weight to the door, it is likely that the hinges will have to be replaced, or a third hinge added, to accept the additional weight. In addition, it makes little sense to upgrade the security of the door without reinforcing the door frame. Sheet steel panels can also be used to line wood shutters on accessible windows.

6.7.4 No. 8 Gauge Wire Mesh Screening.

6.7.4.1 To protect glass panel doors, where it can be possible to break the glass and reach in to unlock the door, or as an alternative to iron bars for protecting windows, transoms and skylights, No. 8 gauge wire mesh screening in a frame can be used. Screens should be bolted in place when installed on the outside, or attached with thumbscrews or a padlock on inside installations where their removal during business hours can be desirable. It is always preferred that screens be installed on the inside of the opening. Large screens [more than 15 ft² (1.39 m²)] should have stiffener bars welded along their centers.

6.7.4.2 Basket-type screens are available that permit the opening of windows for ventilation purposes. Screens can also be hinged and padlocked, with the padlock installed on the inside of the screen to limit its vulnerability to attack.

6.7.5 Sliding or Roll-Up Grilles. Sliding or roll-up grilles of steel, aluminum, or polycarbonate plastic are found in shopping malls, arcades, and building lobbies where they can be used to protect just one store or a series of stores. They are preferred to folding gates, both in appearance (since they are designed to retract out of sight) and in ease of use (since they can be motor driven). Sliding grilles should be provided with a locking device at the top and bottom, while roll-up grilles should be locked in each side guide. In general, they can be manually, chain, or motor operated.

6.8 Glazing Materials. Glazing materials are the family of products that combine the capability of transmitting light, thus providing for surveillance, with the physical ability to absorb high-energy impact while still providing structural integrity. Glazing materials can be burglary resistant or bullet resisting.

6.8.1 Burglary-Resistant Glazing Materials. UL 972 provides performance testing requirements for burglary-resisting glazing materials. These materials are intended for use indoors and outdoors, principally as a substitute for plate (or float) glass show windows and showcase panels. They are designed to resist the hit-and-run (smash-and-grab) type burglary.

6.8.1.1 UL-Listed Burglary-Resisting Glazing Materials. The three types of materials presently listed by UL for use as burglary-resisting glazing materials are laminated glass, polycarbonate, and acrylic. Glazing materials that meet the UL requirements are listed under the category "Burglary-Resisting Glazing Material (CVYU)" in the UL Security Equipment Directory.

6.8.1.1.1 Laminated Glass. This material consists of two sections of $\frac{1}{8}$ in. thick (3.2 mm) glass bonded to an interlayer of 0.060 in. (1.5 mm) or thicker polyvinyl butyryl (PVB). The material is assembled under heat and pressure, causing the glass to bond to the PVB layer. The total thickness of the material is approximately $\frac{3}{32}$ in. (7.1 mm) and is designed to fit the nominal $\frac{1}{4}$ in. (6.4 mm) frame of a show window.

6.8.1.1.2 Acrylic. This material is a plastic sheet of monolithic construction. Acrylic sheets are made by casting or extruding polymerized acrylic ester monomers. It is available in a $\frac{7}{8}$ in. (22.2 mm) thickness.

6.8.1.1.3 Polycarbonate. This material is also a plastic sheet of monolithic construction made by the extrusion or injection molding of polycarbonate resin. It is of $\frac{1}{8}$ in. (3.2 mm) thickness, making it suitable for use in standard size window frames. Polycarbonate has 300 times the impact resistance of plate glass and 20 to 30 times the impact strength of acrylic.

6.8.1.2 Application of UL-Listed Burglary-Resisting Glazing Materials.

6.8.1.2.1 Burglary-resisting glazing materials find application in storefronts, as a replacement for plate glass show windows, and in display cases. Of the three materials that meet the UL requirements for listing as a burglary-resisting glazing material, the polycarbonates exhibit the highest impact resistance while laminated glass has the least. An impact of sufficient magnitude to cause laminated glass to shatter (the pieces of glass tending to adhere to the PVB interlayer) would probably be resisted by the acrylics. In addition, polycarbonate would be able to withstand an impact of much greater magnitude.

6.8.1.2.2 Laminated glass and acrylic are equal optically (both exhibit high clarity) and have good weathering characteristics; polycarbonate is less clear and becomes more opaque as it ages. The plastics weigh 50 percent to 60 percent less than glass, but provide significantly less resistance to scratching.

6.8.1.2.3 Acrylic costs less than laminated glass (although more than plate glass), but it cannot be used in standard window frames because of its thickness. Polycarbonate costs more than laminated glass; however, when replacement costs are factored in, the difference in costs between the two materials can balance out.

6.8.1.2.4 A drawback to the use of laminated glass is that it usually can be cut only at the factory, and so must be ordered cut to size. This somewhat limits its application as a replace-

ment glazing material. The plastics, however, can be cut at the job site with conventional power sawing equipment and can also be drilled, routed, filed, or cemented. This ease of fabrication allows for greater flexibility in their installation.

6.8.1.2.5 In addition to serving as a replacement glazing material for show windows, a plastic panel can also be installed directly behind existing glass to form a second line of defense. For show windows, the polycarbonate sheet is suspended by a hinge at the top, and the bottom is secured to angle irons. This hinged design facilitates cleaning of the glazing surfaces.

6.8.1.2.6 On doors with glass lites or doors adjacent to glazed panels, there is the concern of an intruder breaking the glass and reaching in to unlock the door. To protect against this type of attack, a double cylinder lock (e.g., a lock that requires a key to lock and unlock the door from either side) can be used; however, this application can be in conflict with life safety requirements. An alternative is to use a conventional single cylinder deadbolt and to either replace the glass with burglary-resisting glazing material or to install a polycarbonate sheet behind the glass lite. When used to provide backup protection to a glass lite, the polycarbonate sheet is attached to the door with wood screws and countersunk washers. To allow for the expansion and contraction of the polycarbonate, the holes drilled in the polycarbonate sheet must be of a slightly larger diameter than that of the wood screw. This technique can be applied basically to any type of window.

6.8.1.2.7 The plastics are not as hard or abrasive-resistant as glass. In areas subject to heavy pedestrian traffic, such as the show windows of a jewelry store, laminated glass is preferred to plastics because of its better scratch resistance. Alternatively, plastic glazing can be used behind the glass to provide secondary protection. Plastics are available with special coatings that significantly increase their scratch resistance, but this improvement still does not equal the scratch resistance of glass.

6.8.1.2.8 A potential problem with plastics is associated with their mounting in standard window sashes or window frames. The plastics are subject to greater dimensional change than glass due to thermal expansion and contraction. This fact, combined with their high flexural strength, could result in a determined intruder being able to push the plastic panel out of the window frame before the material itself would break. As such, allowances should be made in the installation of plastic glazing materials to account for this concern. Ideally, a frame with deeper rabbetted dimensions is preferred.

6.8.1.2.9 Both plastics are combustible, requiring that the same fire precautions be observed in their handling and storage as for other combustible materials. One particular concern arises where acrylics are used as a replacement for glass in doors and windows subject to vandalism. Lighter fluid or other flammable liquids can be used to ignite the plastic. Whereas polycarbonate will self extinguish once the source of ignition is removed, acrylic will continue to burn, as well as to emit toxic fumes. The burning acrylic could spread the fire to other combustibles in the building.

6.8.1.2.10 Other materials that find use in resisting forced entry, but are not UL-listed, are called *composites*. Also referred to as *glass-clad polycarbonates*, composites usually consist of a polycarbonate sheet bonded to a glass laminate or sandwiched between two laminations of glass and PVB. They are available in $\frac{3}{8}$ in. (9.5 mm) and greater thicknesses. The composites are scratch resistant and fire resistant, have good weathering characteristics, and exhibit high impact resistance; however, they

cannot be fabricated on the job site, and have to be ordered pre-cut. This factor adds to their cost.

6.8.2 Bullet-Resisting Glazing Materials. UL 752 provides test criteria for glazing materials used to form bullet-resisting barriers that are designed to protect against robbery or holdup. The standard also includes test criteria for the devices and fixtures used in bullet-resisting enclosures. ASTM F 1233 provides test criteria to evaluate the level of resistance of security glazing materials and systems to forced entry due to ballistic impact.

6.8.2.1 UL-Listed Bullet-Resisting Glazing Materials.

6.8.2.1.1 Types of Glazing. Bullet-resisting glazing material can be a laminated assembly of glass and plastic, a combination of glass and plastic or plastic alone bonded together, or it can be monolithic plastic. Four types of bullet-resisting glazing materials are presently listed by UL: laminated glass (also referred to as BR glass), acrylic, polycarbonate, and composites of glass and plastic. Glazing materials that meet the UL requirements are listed under the category "Bullet-Resisting Material" (COGT) and bear the UL Listing Mark.

6.8.2.1.1.1 Laminated Glass. This material consists of various layers of glass bonded together with interlayers of PVB plastic and sealed under heat and pressure. BR glass is available in thicknesses ranging from $1\frac{3}{16}$ in. (30.2 mm) and upwards to provide protection at all ballistic levels.

6.8.2.1.1.2 Acrylics. These materials are usually monolithic in structure and available in thicknesses ranging from $1\frac{1}{4}$ in. to $1\frac{3}{4}$ in. (31.8 mm to 44.5 mm). They provide protection only at the handgun levels and not in the high-power rifle category.

6.8.2.1.1.3 Polycarbonates. Usually of laminated construction, polycarbonates consist of multiple polycarbonate sheets bonded to an interlayer of PVB. They are available in thicknesses ranging from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. (19.1 mm to 44.5 mm). They provide protection only at the handgun levels.

6.8.2.1.1.4 Composites. These usually consist of chemically strengthened glass and polycarbonate sheets that are bonded together with a vinyl-based interlayer to produce a relatively thin, lightweight material. They are sometimes referred to as glass-clad polycarbonates and are available in thicknesses ranging from 0.9 in. (22.9 mm) to more than 2 in. (50.8 mm), providing protection in all the ballistic categories. Other types of composites use combinations of laminated glass, polycarbonate, and/or acrylic separated by an air gap.

6.8.2.1.2 Ratings. UL has established eight ratings for bullet-resisting glazing materials — Levels 1 through 8 — based on the ability of the material to resist penetration from medium-, high-, and super-power small arms; high-power hunting and sporting rifles; submachine guns; assault rifles; and shotguns.

6.8.2.2 Application of UL-Listed Materials. Barriers of bullet-resisting glazing material, also referred to as bandit barriers, are intended to protect personnel from armed robbery attack and to provide them with sufficient time to take appropriate countermeasures. Although these barriers are normally associated with banks, they can be used in any business at risk of armed robbery or attack.

6.8.2.2.1 Laminated Glass. Of the four types of listed bullet-resisting glazing materials, laminated glass is the heaviest. However, it has better scratch resistance and weatherability than the other two, is noncombustible, and is resistant to flame and chemical attack. It does tend to spall more than the

other materials in multiple-shot situations and is vulnerable to smashing under sustained, heavy-impact attack.

6.8.2.2.2 Plastics. The main advantages to the use of plastics are that they are lighter in weight, tend to spall less and afford greater resistance to heavy impact than glass. Also, they can usually be fabricated at the job site. However, the plastics are vulnerable to scratching and, in general, are not as weather resistant as glass — two factors that can affect their cost-effectiveness. Plastics are susceptible to flame and chemical attack, and, being combustible, they increase the fire load in a building.

6.8.2.2.3 Composites. The composites provide a higher degree of attack resistance, greater bullet-resisting capabilities and less spalling than conventional laminated glass. Their primary disadvantage is their cost; they are more expensive than either laminated glass or acrylic.

6.8.2.3 ASTM Testing. ASTM F 1233 provides a basis for the comparative evaluation of ballistic, forced entry, and containment resistance of security glazing materials and systems. It is not intended to establish or confirm the ability of the glazing material to absolutely prevent forcible entries or forced exits. Such materials may be suitable for use in high-risk facilities, such as police stations, guard posts, courtrooms, and detention facilities.

6.8.2.3.1 The test method is used to determine the resistance of the glazing material or system to forced entry by ballistic attack only, or by ballistic attack followed by, and in combination with, physical attack.

6.8.2.3.2 ASTM ballistic tests are performed on 12 in. × 12 in. (305 mm × 305 mm) or 29.75 in. × 29.75 in. (760 mm × 760 mm) test samples at a distance of 25 ft (7.5 m) from the weapon. Spall is detected by perforation of an aluminum foil sheet mounted 6 in. (152 mm) behind the sample. The specifications for the test weapons are provided in Table 3 of ASTM F 1233. Three rounds are fired at the specimen at 120 degree intervals around an 8 in. (20.3 cm) diameter circle and at 0 degree angle of obliquity.

6.8.2.3.3 Five primary ballistic levels – submachine gun, handgun (.44 magnum), handgun (.38 super), rifle, and rifle (AP) – are established based on the ability of the glazing material to withstand the ballistic attack. A sixth level, shotgun, is used to further evaluate the ability of designed-through openings to resist fragmentary threats.

6.8.2.3.4 Glazing materials, depending on their applications, may be required to provide protection against a combination of ballistic and physical attack. In such cases, depending on the level of resistance to forced entry that is desired (e.g., ballistic level and physical attack level), the ASTM ballistic test should be performed followed by the physical attack test.

6.8.2.4 Bullet-Resisting Enclosures. Bullet-resisting enclosures, also referred to as bandit barriers, find application in businesses that are subject to armed robbery, such as banks, check cashing facilities, liquor stores, ticket offices and self-service gas stations. They also find application in municipal buildings, such as post offices and police stations, where workplace violence may be a threat to employees. Bullet-resisting enclosures are intended to enable those being protected to have sufficient time to fully assess a threat and respond with the appropriate countermeasures. While affording protection to personnel, they will also protect the assets of the company and discourage attempts at armed robbery.

6.8.2.4.1 UL Listing. The devices and fixtures listed by UL as being bullet-resisting, and which are used in the construction

of bullet-resisting enclosures, are provided in the UL *Burglary Protection Equipment Directory* under the category “Bullet-Resisting Materials (CNEX).” These listings include bullet-resisting metals and plastics, bullet-resisting glazing materials, bullet-resisting devices, such as deal trays, teller windows and gun ports, and tellers’ fixtures.

6.8.2.4.2 Bullet-Resisting Devices. Bullet-resisting devices include deal trays, vision windows, teller windows, door and frame assemblies, package passers, and gun ports designed to be assembled in bullet-resisting enclosures. A bullet-resisting enclosure should be installed to a height of 7 ft (2.1 m) above the floor and with supplementary mechanical defenses above this height to protect against unauthorized access to the working quarters. In addition, doors that give access to the working quarters should be bullet-resisting and have automatic locks and closers.

6.8.2.4.2.1 Deal Trays. Deal trays are installed in bullet-resisting barriers to provide a means of transferring money and other valuables between the employees’ working quarters and the public space. A deal tray is designed and constructed in such a way that it will not permit a direct line of fire toward the teller’s position, or afford sufficient space for an individual to insert a small caliber handgun in such a manner as to command direct aim on the teller. UL also requires that a deal tray be designed so that a shotgun blast or ricocheted shot coming into the deal tray would be directed away from the teller.

6.8.2.4.2.2 Vision Windows. Vision windows, constructed of bullet-resisting glass or plastic, are installed in bullet-resisting enclosures to provide a secure means for viewing the public space from the protected working quarters. They are available in either fixed or movable forms. Voice communication is accomplished through the use of electronic equipment or by natural means. In the latter case, either a staggered panel arrangement with short return baffles or a baffle system within the window frame is used.

6.8.2.4.2.3 Teller Windows. Teller windows are installed at the point of public interface or transaction and consist of a vision window and a deal tray, through which currency and documents can be passed, on a counter. A teller window usually has a voice communication system.

6.8.2.4.2.4 Door and Door Frame Assemblies. Bullet-resisting doors are constructed of bullet-resisting metals and other materials and are available either as solid doors or with vision panels. Since a bullet-resisting door is considerably heavier than a conventional door, it is important that the door frame be structurally sound and properly reinforced to accept the heavier load. For this reason, the door frame should be also UL listed as bullet-resisting. The lockset should be of the mortise type, with a $\frac{5}{8}$ in. (16.0 mm) throw on the latchbolt, and it should be armored in such a way as to prevent the door from unlatching if subject to a series of shots placed in the areas of the lockset. The door should be equipped with a heavy-duty closer to ensure that the door closes fully with the latchbolt securely latched. Emergency exit and panic hardware are available for use on these doors. The authority having jurisdiction (AHJ) should be consulted for compliance with fire and building codes.

6.8.2.4.2.5 Package Passers. Package passers, also referred to as transfer devices, provide a secure means of transferring relatively large items, such as currency sacks or data processing media, that are too large for a deal tray. These devices are designed with an interlock between the passageway doors such

that only one door can be open at a time, thus always keeping a bullet-resisting barrier between the public space and the working quarters.

6.8.2.4.2.6 Gun Ports. Gun ports are intended to provide personnel with a means to defend themselves against the threat of gunfire, flame, chemical, or mechanical attack. Gun ports are designed for operation from behind the bullet-resisting barrier only, and are equipped with a door or shutter that closes automatically.

6.8.2.4.2.7 Tellers' Fixtures. Bullet-resisting tellers' fixtures are designed for installation in the wall of a bank building to provide a walk-up or drive-in banking facility. Although intended to protect against robbery from the exterior of the building, if they are accessible directly from the working quarters within the bank, the working quarters should be separated from the public space by a bullet-resisting enclosure. A bullet-resisting tellers' fixture is a complete assembly of bullet-resisting glass, metal, and/or plastic; safety deal trays, and usually electrically operated package drawers; a voice communication system; and light fixtures.

6.9 Passive Barriers. In the typical smash-and-grab attack, burglars smash the glass door or show window of a retail store with a sledge hammer or similar tool, grab as much merchandise as can be carried, often while the alarm siren is blaring, and are gone before the police arrive. This type of attack is also called a *3-minute burglary* because the burglars can usually enter the premises and be gone in less than three minutes. Protection against the smash-and-grab attack involves installing roll-down grilles or ferry gates across the front of the store, or replacing the glass with burglary-resisting glazing material. A modern variation on the 3-minute burglary is the *crash-and-grab* attack. In this scenario, the burglars back a pickup truck or other vehicle through the show window of the store, grab merchandise and, again, are gone before the police arrive. While there are no statistics available on the frequency of crash-and-grab attacks, sporting goods stores with their high-value golf clubs have been frequent targets. In addition, there have been reports of as many as 100 burglaries of convenience stores and drug stores where ATM machines were located. In such attacks, the burglars have made off with the ATM machine by loading it onto the truck. The traditional security measures – grilles and gates – will not prevent the crash-and-grab attack. If the store has a grille or gate, the burglars have only to tie it to the truck, pull it off its mountings, and then back the truck through the front of the store. An alarm system only limits the time the burglars will feel they can safely stay on the premises before the police arrive. Burglary-resisting glazing material will not withstand the forces generated by a moving vehicle. The security measure that is most effective against the crash-and-grab attack is that used to protect against terrorist truck bomb attacks: passive barriers.

6.9.1 Concrete Planters. Concrete planters (and bollards, which are discussed in 6.9.2) are being used to protect the White House and other federal government buildings in Washington, D.C.

6.9.1.1 In testing performed by the Corps of Engineers, a concrete planter, designed as shown in Figure 6.9.1.1, was capable of stopping a 15,000 lb (6803.9 kg) vehicle traveling at 50 mph (22.4 m/s). This planter should also stop a 4500 lb (2041.2 kg) vehicle traveling at 30 mph (13.4 m/s), which is approximately the weight of a pickup truck and the likely speed it could attain in a short distance. (Specific information on the design of a planter to stop such a vehicle was not provided in the Security Engineering Manual).

6.9.1.2 If local building or street codes permit their use, and the sidewalk in front of the store is wide enough, a decorative concrete planter placed between the pedestrian walkway and the curb can be used. If more than one planter is required to provide coverage for the front of the store, they should be spaced a maximum of 4 ft (1.22 m) apart.

6.9.2 Bollards. For narrower sidewalks, or as an alternative to planters, bollards can be used. Bollards are 6 ft (1.83 m) to 7 ft (2.13 m) cylinders of steel, usually filled with concrete, and partially buried, leaving a 3 ft to 4 ft (0.91 m to 1.22 m) section above ground.

6.9.2.1 In testing performed by the U.S. Army Corps of Engineers, concrete-filled steel bollards (see Figure 6.9.2.1) spaced

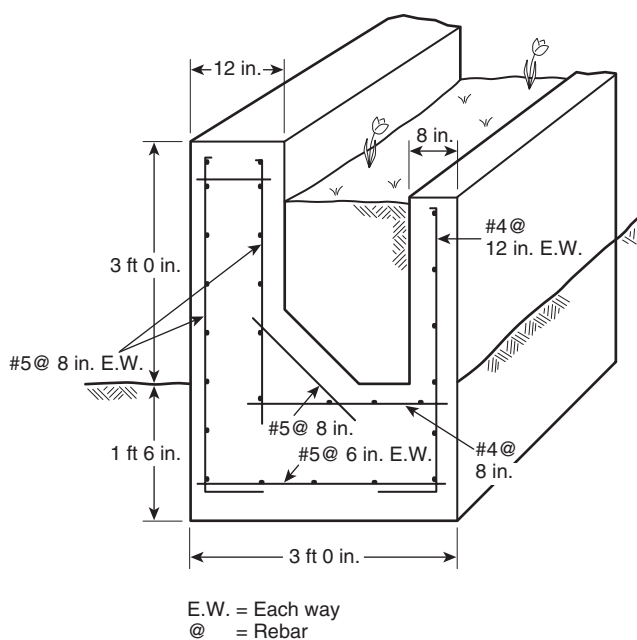


FIGURE 6.9.1.1 Concrete Planter. (Source: U.S. Army Corps of Engineers, Field Manual 19-30.)

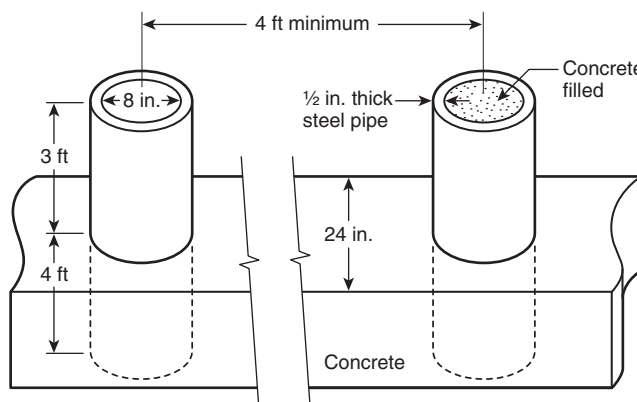


FIGURE 6.9.2.1 Concrete-Filled Bollard. (Source: U.S. Army Corps of Engineers, Field Manual 19-30.)

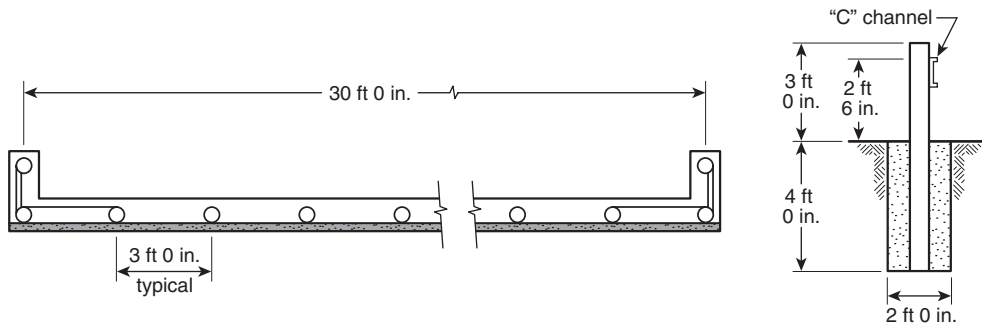


FIGURE 6.9.2.2 Concrete-Filled Steel Bollard with 12 in. “C” Channel. (Source: U.S. Army Corps of Engineers, *Field Manual 19-30*.)

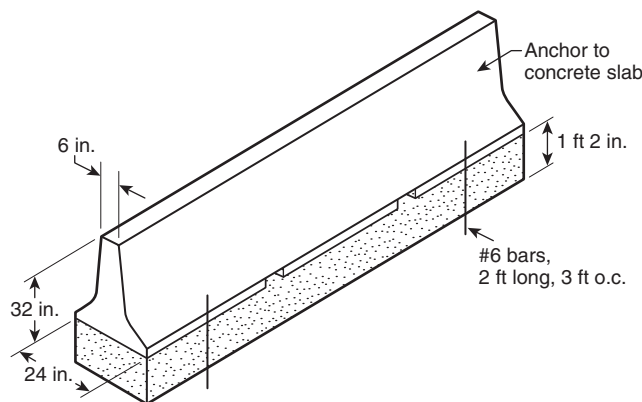


FIGURE 6.9.3 Jersey Barrier. (Source: U.S. Army Corps of Engineers, *Field Manual 19-30*.)

4 ft (1.22 m) apart, at a height of 3 ft (0.91 m) above grade, and buried in concrete to a depth of 4 ft (1.22 m), stopped a 4500 lb (2,041 kg) vehicle traveling at 30 mph (13.4 m/s). The bollard had a diameter of 8 in. (20 cm) and the steel pipe was ½ in. (1.3 cm) thick.

6.9.2.2 When the bollards were reinforced with a 12 in. (0.31 m) “C” channel (see Figure 6.9.2.2), the design was capable of stopping a 15,000 lb (6,804 kg) vehicle traveling at 50 mph (22.4 m/s).

6.9.3 Jersey Barriers. Designed for use on highways as a means of preventing head-on collisions between vehicles, Jersey barriers are also effective in protecting against crash-and-grab attacks. Testing performed by the Army Corps of Engineers found that a Jersey barrier, designed and anchored to a concrete slab (see Figure 6.9.3), was capable of stopping a 4000 lb (1814 kg) vehicle traveling at 50 mph (22.4 m/s). Jersey barriers can be used in place of planters and bollards where aesthetics are not of concern.

6.10 Electronic Perimeter Protection. Electronic perimeter security is applied to a facility to provide a means to detect unauthorized entry onto the property. When the protection is applied at the property line or to outside areas of a facility, it is referred to as *exterior perimeter protection*.

6.10.1 General.

6.10.1.1 Exterior perimeter protection can be applied to fenced areas (such as yards or loading docks where stocks or

materials are stored), to a fence itself, or at the boundary lines where the perimeter is not fenced.

6.10.1.2 Exterior perimeter protection is best applied when the area to be protected is bordered by a fence or other physical barrier, such as a brick or concrete wall. The devices used to provide fence protection, referred to as *fence-mounted sensors*, include electronic vibration detectors and shock sensors. The devices used at unfenced boundary lines, referred to as *buried sensors*, include seismic detectors, pressure detectors, and leaky coaxial cables. The devices used to provide protection to fenced areas, referred to as *volumetric detectors*, include microwave sensors and photoelectric beams.

6.10.2 Fence-Mounted Sensors. Fence-mounted sensors, in general, are intended for installation on chain-link fencing and are designed to detect either the presence of intruders as they approach or touch the fence, or the mechanical vibrations caused by their climbing over, cutting through, or crawling under the fence. Since these devices are mounted directly to the fence, to reduce the potential for false alarms, it is important that the fence be installed according to ASTM F 567. Fence signs should be securely mounted so that they do not rattle, and large bushes and tree limbs that grow along the fence line should be trimmed so that they do not rub against the fence. The primary advantage to the use of fence-mounted sensors is that installation is simplified, since the installer can follow the contour of the fence and the topography of the area. The major disadvantage to their use is that the intruder must come in contact with the fence to be detected.

6.10.2.1 Electronic Vibration Detectors. These devices detect movement of the fence through a set of point transducers that produce an analog signal. An electronic signal processor extracts alarm information from the signal. State-of-the-art equipment provides for processors that can analyze the signal to eliminate false alarms caused by animals, by environmental disturbances (such as wind, rain, and lightning), or by vibrations from nearby activities, such as a passing truck.

6.10.2.2 Shock Sensors. Shock sensors respond to the shock waves created by an impact against the fence. In principle, the shock momentarily displaces a small metal object in the device, interrupting an electrical circuit and generating electrical impulses. A signal processor looks for a pattern of pulses generated over a period of time before signaling an alarm.

6.10.3 Buried Sensors. Buried sensors are usually installed at unfenced boundary lines and provide a narrow, sensitive band,

or detection zone, along the ground above the buried sensors to detect intruders crossing the zone. They can work alone or, in high-risk application, be combined with other outdoor perimeter protection devices to provide a secondary means of detection.

6.10.3.1 Seismic Systems. These systems use passive geophone sensors to detect seismic or acoustic disturbances in the ground and measure these disturbances against a preset value. Systems can consist of a single geophone, called *point sensing*, or a series of geophones around the perimeter. Seismic systems are usually not affected by temperature or weather, but are susceptible to false alarms if installed in areas subject to heavy ground disturbances, such as from vehicular traffic or low-flying aircraft.

6.10.3.2 Pressure Systems. Pressure systems use two liquid-filled hoses buried about 6 in. (152 mm) deep and 5 ft (1.52 m) apart. Each pair of hoses, usually up to 325 ft (99 m) in length, is connected to a pressure-sensing unit or transducer. When an intruder or vehicle passes over the hoses, the liquid hydraulically transmits the ground pressure variations to the transducers, which convert them to electrical impulses.

6.10.3.3 Leaky Coaxial Cables. These cables are ordinary coaxial cables with apertures in them to allow radio frequency energy to leak out. Two cables, one acting as a transmitter and the other as a receiver, are buried in the ground parallel to each other and produce an electromagnetic field. When an intruder enters the detection zone, the electromagnetic field is changed and an alarm is triggered. An advantage to the use of this system is that the electromagnetic field is radiated above and below ground, providing protection against tunnelers.

6.10.4 Volumetric Detectors. Volumetric intrusion detectors are usually applied to fenced areas that are level, such as yards or loading docks where stocks or materials are stored, and generate a narrow, invisible beam (or zone) of electromagnetic energy. The detectors are installed in an overlapping configuration around the perimeter of the facility adjacent to the fence. When an intruder attempts to run, walk, or crawl through this zone, the energy pattern is interrupted, resulting in an alarm condition. Volumetric detectors can also be used with other exterior perimeter protection devices to provide backup protection.

6.10.4.1 Types. Volumetric detectors are either of the microwave or infrared energy type. The energy barrier is formed by a transmitter that sends a signal, a beam of either microwave or infrared energy, to a receiver that is located in the line of sight of the transmitter. The receiver monitors the signal for changes characteristic of an intruder penetrating the beam.

6.10.4.1.1 Outdoor Microwave Systems. These systems are either monostatic, in which case the transmitter and receiver are in the same housing and a mirror is used to reflect back the signal, or bistatic, in which the transmitter and receiver are separate units. Under ideal operating conditions, microwave detectors can usually cover a zone approximately 6 ft to 32 ft (1.8 m × 9.8 m) wide by 5 ft to 13 ft (1.5 m × 4 m) high over ranges up to 650 ft (198 m).

6.10.4.1.2 Infrared Systems. In active infrared systems, the transmitter sends out a beam of pulsed infrared energy to the receiver, and the receiver detects any break in the beam. To create a "fence" of protection, a multiple-beam arrangement, with transmitters and receivers stacked one over the other, can be used. Some units, called transceivers, have the transmitter and receiver in one unit and use a reflector to bounce back

the beam. Long-range outdoor infrared units are available. A curtain of protection can be provided using large-diameter optics. Their use is limited by climatic conditions, since they can be affected by heavy fog, rain, dust, or snow.

6.10.4.2 Installation. Both microwave and infrared detectors should be installed with a clear line of sight between the transmitter and receiver and with the detection zone closely paralleling the ground surface. They should not be used in hilly or uneven terrain, since gullies and dips in the terrain would create voids in the detection zone that could enable an intruder to crawl under the beam without being detected; also, obstructions, such as lampposts, between the transmitter and receiver could block the energy, making detection unreliable. Since these devices are designed to detect movement, all trees, bushes, and tall grass between the transmitter and receiver must be removed, since movement of vegetation by the wind could cause false alarms. Multiple-beam configuration is specifically designed to minimize false alarms.

Chapter 7 Physical Security Devices

7.1 General. This chapter includes descriptions and usage guidance for various types of common physical security devices including builders' hardware, locks, doors, windows, safes, vaults, and strong rooms.

7.2* Locking Hardware. Locks are designed to provide various levels of deterrence or delay entry, and are an integral part of an overall security system. Egress and fire resistance provisions relating to doors and hardware in NFPA 101, *Life Safety Code*; NFPA 72, *National Fire Alarm Code*; and NFPA 80, *Standard for Fire Doors and Fire Windows*, should be maintained. Individual products should be listed to the standards in the following as applicable:

- (1) *ANSI/BHMA A156 Series performance standards include security tests and are shown in the applicable sections.
- (2) UL 1034 for burglary-resistant electronic locking mechanisms.
- (3) UL 437 for key locks.
- (4) UL 768 for combination locks.
- (5) UL 294 for access control system units.
- (6) UL 2058 for high security electronic locks.
- (7) UL 305 for Controlled Exit Panic Devices.

7.2.1 Types of Locks. Locks can be divided into very general classes as follows:

- (1) Those that operate on purely mechanical principles
- (2) Those that are electromechanical and combine electrical energy with mechanical operations
- (3) Electronic

7.2.2 Keys. Keys and locks are often the first and only level of physical security control for many organizational assets. Consequently, key control or the lack of it can mean the difference between a relatively secure activity and extraordinary loss. Almost all organizations utilize some type of key access in everyday operations. Each day offers an opportunity for key mismanagement or unauthorized duplication, which can lead to mild annoyances such as the replacement and cost for lost keys, or to more serious losses, such as theft or personal injury. A good key control system will maintain a strict accountability for keys and limit both key duplication and distribution. Refer to ANSI/BHMA A156.28. Keys should meet ANSI/BHMA

A156.5 Cylinder Section, and ANSI/BHMAA 156.30 in the appropriate grade for the application.

7.2.2.1 Types of Keys and Cylinders. Proprietary keyways or patented cylinder and key mechanisms are available with controlled distribution to prevent unauthorized key duplication. When they are combined with any of the various locking hardware described below, consideration should be given to the need for a patented high security or patented key control cylinder on keyed functions. Operating or “change” keys are keys that are used to open locks. Duplicate keys are copies of operating keys and are usually stored for use in an emergency or to replace a lost key. Duplicate keys must be kept to a minimum and be protected to avoid proliferation and loss of accountability. Master keys are designed to open all locks of a particular series. Key systems can have one grandmaster key for the overall system and several sub-master keys for each subsystem. Master keys can be used as a convenience, for example, carrying one key instead of numerous keys, but their use increases susceptibility to picking and duplication and must be carefully controlled. Construction keys open removable core lock cylinders installed on the doors during construction of a facility. These cores are replaced at the end of construction with cores subject to the facility’s key system. Control keys are used to remove and replace these cores. Control keys are used only in interchangeable core cylinder systems.

7.2.2.2 Key Accountability Procedures. The integrity of a key system is important to safeguarding property and controlling access. Lost or stolen keys and keyblanks can compromise the security of a key system. The security officer should ensure that responsible individuals maintain control over the facility’s key system by storing, issuing, and accounting for all keys under the facility’s control. Issuance of keys must be kept to a minimum. Keys should be issued only to persons who have an official need. Accurate accountability records must be kept and should contain the information listed in 7.2.2.2.1 and 7.2.2.2.2. PC-based software and key storage cabinets and computer-controlled key retention and distribution systems are available to facilitate the management of a master key system and help to ensure its long-term integrity.

7.2.2.2.1 Procedures should include the following:

- (1) When a key to a designated controlled or restricted area is lost, the locks to the area must be changed.
- (2) Access lists for persons authorized to draw master keys should be maintained.
- (3) The key storage container/cabinet should be kept locked with a pick- and drill-resistant, patented high security cylinder that is not keyed to the facility master key system.
- (4) The container/cabinet should be checked periodically in accordance with the security plan.
- (5) All keys should be inventoried at least annually.
- (6) Requests for issuance of new, duplicate, or replacement keys should be made in writing, and approved or monitored by the security officer.
- (7) Keys not issued or no longer needed should be destroyed or stored in a locked container.
- (8) Protection of keys should be a priority at all times.
- (9) Identifying key tags with user or facility names on rings is not recommended; if keys are lost, it’s an open invitation for misuse.
- (10) Keys should not be left on desks, in unlocked drawers, or where they can be easily taken and copied.
- (11) Employees should be reminded to keep official keys on their person or securely locked in a desk or cabinet, and

that they are not to lend them to individuals not specifically authorized.

- (12) Employees should promptly return official keys checked out on a temporary basis.
- (13) Lost keys should be immediately reported to the appropriate official, and locks should be rekeyed immediately and new keys issued when keys are lost or stolen.
- (14) Keys should not identify the specific premises or access doors which they open.

7.2.2.2.2 Records should include the following:

- (1) Number assigned to each key and lock
- (2) Location of each lock (room number)
- (3) Person to whom keys have been issued
- (4) Date of issuance
- (5) Recipient’s signature for keys issued

7.2.3 Electronic Cylinders. Electronic cylinders are useful in applications where there is a high user turnover and a need to collect access data, and limit access to particular periods. They are often used in conjunction with card readers, biometrics, and so on. Electronic cylinders should meet the requirements of ANSI/BHMAA156.30 in the appropriate grade for the application.

7.2.4 Flush Bolts. Flush bolts are used in pairs of door openings requiring only one leaf for normal use or to meet an exiting requirement where the occasional use of a larger opening is required. Flush bolts are small deadbolts that go into the floor and ceiling and typically keep the second door in a pair of doors closed. Flush bolts are frequently used on pairs of doors in conjunction with a lock or exit device on the active leaf. Flush bolts can be either manual or automatic. Automatic (not manual) flush bolts are used on the inactive leaf of a fire-rated door in a pair of doors. Automatic bolts use the closing action of the active leaf to activate the latching. Periodic inspection for warped, weakened, or otherwise misaligned doors should be conducted to assure activation of top and bottom bolts. This inspection should include a check to assure that there are no obstructions or foreign objects in frame or floor strikes. In non-fire-rated applications, manual flush bolts secure the second door in a pair. Key lockable flush bolts are surface applied and can be used to prevent inactive leaves of a pair from being opened.

7.2.5 Coordinators. A pair of doors often require a coordinator. These devices mount on the top jamb and hold one door open until the other door closes, which allows the door to latch shut properly. Without a coordinator, doors can be easily inadvertently left propped open.

7.2.6 Built-In Locks. When a security container or vault door is used to safeguard confidential information, it should be listed and equipped with a lock designed to prevent the user from leaving the container in the “closed but unlocked” condition.

7.2.7 Combination Locks. A manipulation-resistant combination lock provides a high degree of protection. It is used primarily for safeguarding classified or sensitive material. Its technical design is to prevent the opening lever from coming in contact with the tumblers until the combination has been dialed. These locks are available with mechanical or electronic dials.

7.2.8 Combination Padlocks. Combination padlocks are used primarily on a bar-lock filing cabinet. They are not rated for resistance to physical attack and are not recommended for outdoor use. The procedures for changing combinations, protecting combinations, and recording combinations established in 7.2.2.2 should also be followed for combination padlocks.

7.2.9 Exit Devices.

7.2.9.1 Exit devices are used where occupancy levels require unimpeded single-motion egress. Typical locations include at an opening from an area of assembly and at all latched openings in the direction of the building exit. Exit devices are also required in hazardous locations, often so designated because of gas, chemicals, or flame. Selection of an exit device should include an evaluation of the environment. Nonfire devices can be equipped with “dogging,” which holds the latch(es) retracted for extended periods of time. This makes entry easier, reduces wear, and allows designers to use pulls instead of functioning trim to limit vandalism.

7.2.9.2 In areas exposed to abuse, the use of vertical rods should be limited to those locations where they are the only acceptable alternative. Additional steel covers to retard damage can protect rods. Surface vertical rods are susceptible to bending and other damage by carts. For security as well as fire code compliance, vertical rod latches must latch at top and bottom; otherwise, flexing in the door can allow criminal entry. Use of a threshold with vertical rods will provide a better mounting surface for bottom strikes. Vertical rod deadbolt exit devices provide further resistance to forced entry.

7.2.9.3 Cross-corridor double egress pairs of door openings typically require vertical rods in pairs. Pairs of doors swinging in the same direction can either be vertical by vertical or vertical by mortise exit device. When fire doors are required to have an overlapping astragal, the use of a vertical by mortise system is required. The latter application also requires a coordinator. The securest approach to pairs of doors swinging in the same direction is to use a mullion and two rim or mortise devices.

7.2.9.4 Electrified exit devices are available in various functions. Electric dogging will hold the latch retracted once the power is applied, rendering push pull operation. Electric latch retraction allows dogging the device without going to the device. Both of these applications are convenient for fire-rated exits that are not permitted to be mechanically dogged. Electric latch retraction can be combined with an access control system to provide controlled entrance even on pairs of doors that latch at the top and bottom. Electric latch retraction can be combined with an auto-operator to provide access for the physically impaired. Electric strikes or electric control trim can be added to exit devices to provide electric release.

7.2.10 Bored/Cylindrical Locks. These lock designs provide convenient installation along with moderate security. Different locking functions are offered to meet access needs, such as nonkeyed locking (for bathroom) and keyed entry. For enhanced resistance to forced entry, doors with these locks can have a separate deadbolt mounted on the door, depending on local codes, as the second lock requires two actions for egress. Recent product developments have greatly increased the strength and durability of these locks in order to retrofit existing installations with more secure locking solutions. These locks should meet ANSI/BHMA A156.2 and UL 437 in the appropriate grade for the application.

7.2.11 Interconnected Locks. These lock designs combine cylindrical locks and deadbolts and are used in residential occupancy where one motion is required to open the door. They include independently installed cylindrical and deadbolt locks that contain a linkage that allows instant retraction of the deadbolt with movement of the interior lever handle or knob. They combine the security and safety of a latching de-

vice with the security of a deadbolt. These locks should meet ANSI/BHMA A156.12 and UL 437 in the appropriate grade for the application.

7.2.12 Mortise Locks. These lock designs are typically used in institutional and high-rise residential applications. They can incorporate both a latch and deadbolt in the same body. Mortise locks allow a deadbolt with latch in a path of egress by retracting the latch and deadbolt in a single motion. Mortise locks can be designed with a low-cost failure point, shear pin, spindle, and so forth, making their application attractive for locations that are apt to receive a lot of abuse. Mortise locks should meet ANSI/BHMA A156.13 and UL 437 in the appropriate grade for the application.

7.2.13 Electromechanical Locks. Electromechanical door locks are primarily used to control entry into an area. They can be opened via key (mechanically activated) or electrically by receiving power from a power supply after the valid presentation of a code to a secure encrypted electronic credential (e.g. mag-stripe card, proximity card, smart card, digital keypad). They can also be remotely activated by a simple pushbutton or intercom system. Some of the advantages of using these locks are code compliant operation, low cost, easy installation, simple operation, and integration with access control systems. Electromechanical should meet ANSI/BHMA A156.25 in the appropriate grade for the application. Electrified locking devices should also meet the performance requirements as defined by the applicable ANSI/BHMA A156 standards for the product and grade specified by the manufacturer and listed to UL 1034.

7.2.14 Electromagnetic Locks. These lock designs provide reasonably high levels of force resistance in high traffic access controlled areas. The use of electromagnetic locks must not alter the requirement for fire-rated hardware or single-motion egress. Electromagnetic locks should meet ANSI/BHMA A156.23 in the appropriate grade for the application and listed to UL 1034 for burglary-resistant electric locks.

7.2.15 Delayed Egress Locks. Delayed egress locks were designed for use in retail applications and are valuable in many applications to provide reasonable security by operating on a delay with an alarm in non-emergency situations. They can only be installed where permitted by code and must be released instantly (without delay) by the fire alarm system in the event of emergency. They should meet ANSI/BHMA A156.24 in the appropriate grade for the application and be listed as “Special Locking Arrangements.”

7.2.16 Electric Strikes. Electric strikes provide electric release via access control or pushbutton interface for use with bored/cylindrical locks, mortise locks, or exit devices. Models are available for use in both fail-safe and fail-secure situations. Fail-safe models cannot be used in high-rise stairwell applications where codes require re-entry to every fourth floor in the event of a fire, as these are fire-rated doors and the positive latching is lost in this mode. Fail-safe models can be used on non-fire-rated traffic control doors. There are many varieties of electric strikes offering varying levels of protection against forced entry. Electric strikes should be used only where the door frame or the surrounding wall structure is sufficient to prohibit access to strike components or wiring. Electric strikes should meet ANSI/BHMA A156.31 in the appropriate grade for the application and should be listed to UL 1034 for burglary-resistant electric door strikes.

7.2.17 Electrified Trim. Electrified trim can be used in place of electromechanical locks or electric strikes and can provide

a high level of resistance to forced entry. Electric trim can be used with bored/cylindrical locks, mortise locks, or exit devices. They typically would provide keyed or electric entry. They can be used in either fail-safe or fail-secure configurations.

7.2.18 Deadbolts and Auxiliary Deadbolts. These products provide an added degree of security due to their longer throw and positive deadlocking. Auxiliary deadbolts are used to protect perimeter doors where not prohibited by codes requiring single motion egress and are also used on interior doors for forced-entry resistance. The use of auxiliary deadbolts is often prohibited in conjunction with another lock when in a path of egress, as this would require two separate motions and can be confusing to a person during an emergency. Double-cylinder auxiliary deadbolts provide a high level of security, particularly when there are glass panels in the vicinity of the lock, but local codes should be checked for allowable applications. Deadbolt exit locks and deadbolt exit devices provide a higher degree of resistance to forced entry and can be used on doors requiring single-motion egress. The only deadbolts permitted on fire-rated exit doors are those that provide self-relocking. Mortise locksets that contain both a latch and deadbolt can contain single-motion release for use on doors in the path of egress and fire-rated doors. Multi-point deadbolt locks are available in a wide variety of functions and types (surface-mounted, mortise, exit device) and provide the highest level of resistance to forced entry attempts. Auxiliary deadbolts should meet ANSI/BHMA A156.5, "Deadbolt Section," and UL 437, "Door Locks," in the appropriate grade for the application.

7.2.19 Hinges. Hinges or pivots are required for all swinging doors. Hinges other than continuous hinges should be installed at intervals of every 30 in. (76.2 cm). Nonremovable pins (NRP) should be used on hinges accessible from the outside (out-swinging doors). Various types of security studs are available to prevent attack. They should meet ANSI/BHMA A156.1 or A156.26 in the appropriate grade for the application.

7.2.20 Door Closers and Spring Hinges. These devices will automatically close the door after opening ensuring latching or locking. They are essential for security due to the fact the door cannot latch if it is not closed. Also many door closers include a "hold open" feature that will allow a door to be held in the open door position without using dangerous and inconsistent devices such as a rock, brick, or wedge to keep the door open. They should meet ANSI/BHMA A156.4 or ANSI/BHMA A156.17, "Spring Hinges," in the appropriate grade for the application.

7.3 Doors.

7.3.1 A door is a vulnerable point of the security of any building. The best door is of little value if there are exposed removable hinge pins, breakable vision panels, or other physical weaknesses that would allow entry. A secure door is made of metal or solid wood. Steel doors produced to ANSI/SDI A250.8 and tested to ANSI/SDI A250.4 and wood doors are tested for security. Door strength and reinforcement should be compatible with the locks used.

7.3.2 Non-exit doors should be installed so the hinges are on the inside to preclude removal of the screws and pins or the use of chisels or cutting devices. Exit door exterior hinges should be protected by welded, flanged, or otherwise secured pins, or hinge dowels should be used to preclude the door's removal.

7.3.3 An operable or glazed transom should be protected by permanently sealing it, locking it from the inside with a sturdy

sliding bolt lock or other similar device, or equipping it with bars or grills.

7.3.4 The security measures outlined in this section are designed specifically to increase the resistance of doors to illegal entry. All doors should be secured with a locking mechanism. Consideration should be given to the structure of the opening and the surrounding wall, so that the ability to provide a secure locking device is not compromised.

7.3.5 Exterior doors should be of a solid-core design or steel construction with hinges on the interior of the door (in residential applications and where permitted by codes) and a keyed lock with a strike bolt into a solid frame. Frames should be fastened to the wall studs by using long screws to insure the door's stability. Strike plates should also be firmly fastened to the frame to avoid being ripped out.

7.3.6 Other security measures that should be considered for doors are described in 7.3.6.1 through 7.3.6.9.

7.3.6.1 Assuming exterior doors are of solid construction, they should be equipped with a good deadbolt with at least a 1 in. (25.4 mm) throw lock as described in 7.2.18.

7.3.6.2 Exterior doors must fit tightly in the frame with no more than 1/8 in. (3.2 mm) clearance between the door and frame. If the gap is too large, replace the door or install a sturdy metal strip or latch guard to the door edge to cover the gap. Deadbolts or locks with deadlocking latches help prevent entry from manipulating the bolts through the gap.

7.3.6.3 The hinged side on outward swinging doors should be protected by using nonremovable hinge pins or hinges that incorporate security studs. Where practical, projecting pins that fit snugly into sockets in the door jamb when the door is closed should be installed in the hinged edge of the door. This will prevent attempts to open the door on the hinged side by removal of the hinge pin or by cutting off the hinge knuckle.

7.3.6.4 If an exterior door has a glass panel within 40 in. (101.6 cm) of the lock, replace the glass with UL-listed burglary-resisting glazing material, such as polycarbonate glazing. Alternatively, a piece of polycarbonate can be attached to the inside of the door behind the glass to provide backup protection, or the glass panel can be protected with a metal security screen. This will prevent a burglar from breaking the glass and reaching in to unlock the door.

7.3.6.5 Glass panels or inserts along with side panels should be addressed when determining the appropriate locking mechanism. Glass panels can easily be broken by intruders. Consider covering the glass with a break-resistant panel, burglary-resistant glazing, or decorative grill.

7.3.6.6 Install and adjust the rollers on sliding glass patio doors so that a burglar cannot lift the doors out of their tracks and remove them. The rollers can be adjusted so that the door cannot be pushed up enough to lift it off the track. Alternatively, a projecting screw placed in the track above the door or a nail inserted through the inside frame and partway through the metal door frame will prevent the door from being lifted out of the track. The same techniques can be applied to sliding windows. Secure stationary doors with locks and long screws to avoid removal.

7.3.6.7 Place a wooden dowel or a patio door bar into the track of a sliding patio glass door. This will positively block the travel of the sliding portion of the door even if the lock is

broken, since the lock catch on sliding glass patio doors can usually be easily pried out of the soft aluminum door frame.

7.3.6.8 Secure exterior doors to basements, (particularly “dog-gie doors”) on the interior with a slide bolt, or on the exterior with a heavy-duty padlock that has a hardened steel hasp.

7.3.6.9 For doors without glazed panels, a wide-angle door viewer installed into the door provides the opportunity to view the exterior before opening the door. Door viewers meeting ANSI/BHMA A156.16 are available in three viewing angles to suit the application: Grade 1, 185 degrees; Grade 2, 145 degrees; and Grade 3, 115 degrees.

7.3.7 Specialty doors include those described in 7.3.7.1 through 7.3.7.4.

7.3.7.1 Coiling doors should be protected with slide bolts on the bottom bar unless they are controlled or locked by electric power.

7.3.7.2 An iron keeper for securing the hand chain or an iron pin for the shaft on the crank should be provided.

7.3.7.3 Solid overhead, swinging, sliding, or folding doors should be protected with a cylinder lock or padlock. A metal slide bar, bolt, or crossbar should be provided on the inside.

7.3.7.4 Metal accordion grate or grill-type doors should have a secured metal guide track at the top and bottom and be secured with a cylinder lock or padlock.

7.4 Windows.

7.4.1 Windows are another vulnerable point for gaining illegal access to a building. The window frame must be securely fastened to the building so that it cannot be pried loose. As with glass panels in a door, window glass can be broken or cut so the intruder can reach inside and release the lock.

7.4.2 Windows should be secured on the inside using a window lock, locking bolt, slide bar, or crossbar with a padlock. Under no circumstances should any window lock or bars that are installed in a premises deviate from building and fire code requirements for emergency egress.

7.4.3 Bars should be steel of at least ½ in. (12.7 mm) in least dimension and spaced 6 in. (152.4 mm) apart on center. If a grille is used, the material should be at least number nine gauge 2 in. (50.8 mm) square mesh. Bars and grills must be securely fastened to the window frame so they cannot be pried loose.

7.4.4 Outside hinges on windows should have nonremovable pins. The hinge pins should be welded, flanged, or otherwise secured so they cannot be removed.

7.5 Security Vaults. A vault is a completely enclosed space with a high degree of protection against forced entry. Vaults are commonly used for storing cash, information, and valuable property. The protection provided by the vault walls, ceiling, floor, and door(s) should be equivalent. For an enhanced level of protection, vaults should be used in combination with intrusion detection systems.

7.5.1 Classification of Vault Walls. The ANSI/UL classification system for burglary-resistant modular vault panels is based on the length of time the vault will resist the efforts of skilled technicians, using tools and torches, to make a significant penetration. The four classifications are: Class M, ¼ hour; Class 1, ½ hour; Class 2, 1 hour; Class 3, 2 hours. The classifications indicate that a vault, constructed with a UL-listed door and modular panels, will resist attempts at entry, using the tools and techniques specified

in the standard, for attack times varying from 15 minutes to 2 hours. Entry is defined as opening the door or making a 96 in.² (619.4 cm²) opening entirely through the door or door frame, the modular panel, or a seam joining two or more modular panels. The smallest dimension of the opening must be at least 6 in. (15.2 cm).

7.5.2 Alternate Vault Wall Constructions. The UL 608 standard for burglary-resistant vaults is performance based and allows for alternative construction materials. Over the years, however, many types of vault construction have been used, with the type chosen for a particular situation determined by the construction and load capacity of the building. For example, in a high-rise building designed for a maximum floor live load of 100 lb/ft² (450 kg/m²), a conventional vault with reinforced concrete walls would not be chosen, unless extensive structural reinforcement of the building was possible.

7.5.3 Construction Materials. The materials used in constructing vault walls include reinforced concrete, steel lining, reinforced concrete blocks, or a combination of these materials.

7.5.3.1 Reinforced Concrete.

7.5.3.1.1 The majority of vaults built in the past had walls made of reinforced concrete. Vault walls of this type are usually referred to as generic vault walls. Such walls are very heavy, however, limiting their use to locations that can accept heavy floor loads, such as a basement or a ground floor that has been structurally reinforced. When floor loading is not a concern, such as in basement or grade locations, reinforced concrete can be used for the vault walls, floor, and ceiling. Protection equivalent to a UL-listed modular vault panel can be obtained using reinforced concrete.

7.5.3.1.2 ASTM F 1090 provides the following equivalencies for reinforced concrete to UL-listed vault doors and modular panels (*see Table 7.5.3.1.2*):

- (1) A 9 in. (22.9 cm) thick reinforced concrete wall will provide protection equivalent to a Class M panel.
- (2) A 12 in. (30.5 cm) thick wall, a Class 1 panel.
- (3) An 18 in. (45.7 cm) thick wall, a Class 2 panel.
- (4) A 27 in. (68.6 cm) thick wall, a Class 3 panel.

7.5.3.1.3 ASTM F 1247 provides the following guidelines for the construction of reinforced concrete (generic) vaults:

- (1) The concrete should have a minimum compressive strength of 4000 psi (125.0 kg/m²), and the reinforcing should be one of the following types:
 - (a) #5 rebars located in horizontal and vertical rows to form grids spaced 4 in. (10.2 cm) on center and parallel to the face of the wall
 - (b) Grids of expanded steel bank vault mesh, weighing at least 6 lb/ft² (27.0 kg/m²), and having a diamond pattern not more than 3 in. (7.6 cm) by 8 in. (20.3 cm), placed parallel to the face of the wall and spaced 4 in. (10.2 cm) on center
- (2) The reinforcing should be placed in the vault walls, floor and ceiling as follows:
 - (a) For a 9 in. (22.9 cm) thick wall, 2 grids of expanded metal or rebars
 - (b) For a 12 in. (30.5 cm) thick wall, 2 grids of expanded metal or 3 grids of rebars
 - (c) For an 18 in. (45.7 cm) thick wall, 3 grids of expanded metal or 4 grids of rebars
 - (d) For a 27 in. (68.6 cm) thick wall, 4 grids of expanded metal or 5 grids of rebars

Table 7.5.3.1.2 Reinforced Concrete Equivalencies to UL-Listed Vault Doors and Modular Panels

UL Classification	Thickness of Reinforced Concrete		Reinforcement No. of Rows of #5 Rebars	Reinforcement No. of Grids of Expanded Metal
	in.	cm		
Class M	9	22.9	2	2
Class 1	12	30.5	3	2
Class 2	18	45.7	4	3
Class 3	27	68.6	5	4

7.5.3.2 Laminated Panels.

7.5.3.2.1 A steel/ply system consisting of two layers of 9-gauge low-alloy steel sandwiching a sheet of $\frac{3}{4}$ in. (1.9 cm) thick exterior grade plywood was found to afford good protection against attack by drilling, sawing, and cutting. In testing performed by a government laboratory, the laminated panel resisted, for approximately 15 minutes, attempts to make a 9 in. $\times$ 12 in. (22.9 cm $\times$ 30.5 cm) opening with an electric drill, an electrically powered reciprocating hacksaw, and an oxygen lance. (For comparison purposes, a steel plate of equal thickness was penetrated in less than three minutes with the oxygen lance.) An additional 5 minutes of protection was achieved by placing 90 lb (40.8 kg) gravel finish roofing paper next to the steel layers.

7.5.3.2.2 An advantage of the steel/ply system, besides its light weight, is that it can be used to retrofit the walls, floor, and ceiling of a vault lacking in burglary resistance. The sheets of steel and plywood, either fastened or bonded together, can be precut and carried to the job site for installation as a liner in an existing vault.

7.5.3.3 Steel Lining.

7.5.3.3.1 Plates of steel are used to construct vault walls because their light weight, when compared to other materials, allows for their application in high-rise structures where floor loading can be a concern. Steel plate, without other protective materials, is unacceptable for vault wall construction because it is very vulnerable to torch attack. Although it can provide protection against common hand tools, steel affords minimal protection against a torch.

7.5.3.3.2 In prior testing by UL, making a “manhole” size opening with a torch in a $\frac{1}{2}$ in. (1.3 cm) thick steel plate took less than 2 minutes, a 1 in. (2.5 cm) thick plate withstood attack for about 3 minutes, and a $1\frac{1}{2}$ in. (3.8 cm) thick plate lasted a little less than 4 minutes.

7.5.3.4 Reinforced Concrete Block.

7.5.3.4.1 Vault walls also can be constructed of 8 in. (20.3 cm) or 12 in. (30.5 cm) thick concrete blocks filled with concrete and reinforced with steel rods. This method of vault construction has gained acceptance because it is less expensive and lighter than a reinforced concrete wall, making it suitable for use in some high-rise buildings without extensive structural reinforcing. Walls of this type are often backed by $\frac{1}{2}$ in. (1.3 cm) or 1 in. (2.5 cm) steel lining to improve their security.

7.5.3.4.2 Vault walls of reinforced concrete block with steel lining (often referred to as a *jeweler’s special*) provide a level of protection better than that of steel lining but not as good as that from a reinforced concrete wall of equal thickness. It is preferred that a listed lightweight modular panel be used in place of reinforced concrete block.

7.5.4 Vault Doors. The ANSI/ UL classification system for burglary-resistant vault doors is based on the length of time the vault will resist the efforts of skilled technicians, using tools and torches, to make a significant penetration. The four classifications are directly related to vault constructions and should meet or exceed that of the overall vault modular panels rating: Class M, $\frac{1}{4}$ hour; Class 1, $\frac{1}{2}$ hour; Class 2, 1 hour; Class 3, 2 hours.

7.6 Strong Rooms.

7.6.1 Description. A strong room is an enclosed space constructed of solid building materials. Strong rooms are normally used for the storage of classified material or sensitive materials, such as firearms. Protection is normally supplemented by guards or alarm systems. Rooms that have false ceilings and walls constructed of fibrous materials, and other modular or lightweight materials cannot qualify as strong rooms.

7.6.2 Construction Standards.

7.6.2.1 Heavy-duty builder’s hardware should be used in construction. All screws, nuts, bolts, hasps, clamps, bars, hinges, and pins should be securely fastened to preclude surreptitious entry and to assure visual evidence of force entry. Hardware accessible from outside the strong room must be peened, brazed, or spot welded to preclude removal.

7.6.2.2 Walls and ceiling should be made of plaster, gypsum board, metal, hardboard, wood, plywood, nine gauge or heavier 2 in. wire mesh, or other material of sufficient strength or thickness to deter entry and/or give evidence of unauthorized entry. Insert-type panels should not be used.

7.6.2.3 Floors should be solidly constructed using concrete, ceramic tile, or wood.

7.6.2.4 Windows, that open and are less than 18 ft from an access point (such as the ground, another window outside the area, roof, ledge, or door) should be fitted with $\frac{1}{2}$ in. horizontal bars and crossbars). In place of bars, number 9 gauge wire mesh can be fastened by bolts extending through the wall and secured on the inside of the window board. Windows should be kept closed and made opaque by any practical method.

7.6.2.5 Where ducts, registers, sewers, and tunnels are of such size and shape (in excess of 96 in.² inches and over 6 in. in its smallest dimension) as to permit unauthorized entry, they should be equipped with man-safe barriers such as wire mesh or steel bars.

7.6.2.6 Doors should be substantially constructed of wood or metal. When windows, panels, louvers, or similar openings are

used, they should be secured with 18 gauge expanded metal or wire mesh securely fastened on the inside of the room.

7.7 Safes.

7.7.1 Designed Resistance. Safes are designed to be burglary-resistant or fire-resistant. Not all fire-resistant safes are burglary resistant.

7.7.2 Classification of Burglary-Resistant Safe. UL 687 classifies burglary-resistant safes according to the length of time the safe will resist various methods of expert burglary attack.

7.7.2.1 Tool-Resistant Safe — Class TL-15.

7.7.2.1.1 This represents a combination locked steel chest, weighing at least 750 lb (340 kg) or with means for anchoring it in a larger safe, in concrete blocks, or to the premises, that is designed to offer protection for 15 minutes against entry by common hand tools, picking tools, mechanical or portable electrical tools, grinding points, carbide drills and pressure-applying devices. Entry is defined as opening the door or making a 6 in.² opening entirely through the door or front face.

7.7.2.1.2 The metal used in the body of the safe usually is open-hearth steel 1 in. (2.54 cm) thick with an ultimate tensile strength of 50,000 psi (345 Mpa), or ½ in. thick steel with an ultimate tensile strength of 100,000 psi (690 Mpa). Materials other than steel can be used if, in testing by UL, they can be shown to provide equivalent resistance to attack.

7.7.2.1.3 The door of the safe is usually of steel at least 1½ in. (3.81 cm) thick with hardened steel plate on the inside of the door to protect the locking mechanism. Composite materials (i.e., metal alloys) can be substituted for the steel if their attack resistance is equal to or better than that for steel. The safe is required to have a combination lock, complying with UL 768 of Group 2M, 1, 1R; or UL 2058.

7.7.2.1.4 The UL tests on TL-15 and deposit safes are limited to the door and front face only. Using pressure-applying devices and carbide drills, the body of these safes can be easily penetrated. They should be clad in concrete to improve their burglary resistance. Their use should be limited to low-risk situations where inventory values are kept to a minimum.

7.7.2.2 Tool-Resistant Safe — Deposit Safes. This safe is similar in design to the TL-15 safe, except that it is provided with a mechanism for making money deposits. Since the safe is designed to receive envelope and deposit bags, UL performs fishing and trapping tests on this safe to determine its resistance to these methods of attack. The safe is required to weigh at least 750 lb (340 kg) and have a combination lock, complying with UL 768 of Group 2M, 1, 1R; or UL 2058, Type 1.

7.7.2.3 Tool-Resistant Safe — Class TL-30. The body and door of this safe are very similar in design to that of the TL-15 safe, with the exception that the hardened steel plate, used to protect the lock mechanism, usually extends over the entire face of the door. This safe is required to resist entry, defined as opening the door or making a 6 in.² opening entirely through the door or front face, for 30 minutes using the same tools specified for the TL-15 safe and including abrasive cutting wheels and power saws. The safe is required to weigh at least 750 lb (340 kg) and have a combination lock, complying with UL 768 of Group 2M, 1, 1R; or UL 2058, Type 1. The same limitations in the use of the TL-15 safe apply to this safe, since the safe's body is vulnerable to attack. Encasing the safe in reinforced concrete will improve its performance.

7.7.2.4 Tool-Resistant Safe — Class TL-15x6. This upgraded version of the "door only" TL-15 safe provides equivalent protection on all six sides, thus the x6 nomenclature. The body and door of these safes usually are built of composite materials that can resist attack from common hand tools and abrasive cutting wheels and power saws. Entry is defined as opening the door or making a 6 in.² opening entirely through the door or body of the safe, as compared to just the door and front face for the TL-15 and TL-30 safes. The safe is required to weigh at least 750 lb (340 kg) and have a combination lock, complying with UL 768 of Group 2M, 1, 1R; or UL 2058, Type 1.

7.7.2.5 Tool-Resistant Safe — Class TL-30x6. Like the TL-15x6 safe, this is an upgraded version of the "door-only" TL-30 safe. This safe provides a moderate degree of burglary protection on all six sides. Entry is defined as opening the door or making a 6 in.² opening entirely through the door or body of the safe. The safe is required to weigh at least 750 lb (340 kg) and have a combination lock, complying with UL 768 of Group 2M, 1, 1R; or UL 2058, Type 1.

7.7.2.6 Torch- and Tool-Resistant Safe — Class TRTL-30.

7.7.2.6.1 This represents a combination-locked safe weighing at least 750 lb and having a body constructed of solid open-hearth steel, at least 1 in. (2.54 cm) thick with a tensile strength of 50,000 psi (345 Mpa). The body of the safe is required to be encased in reinforced concrete, at least 3 in. (7.62 cm) thick with a minimum compressive strength of 4,000 psi (27.6 Mpa). Materials other than solid metal encased in concrete can be used if it can be shown to provide equivalent resistance to attack.

7.7.2.6.2 The UL tests on this safe are restricted to the door and front face only; no tests are performed on the body of the safe. The door and front face are required to resist attack using the same tools as for the TL-30 safes, and including an oxyacetylene torch. The protection to torch attack is achieved through the use of copper or an alloy material in the door and front face that is intended to help dissipate the heat of the torch. This is the lowest rated UL safe that permits attack using an oxyacetylene torch.

7.7.2.6.3 Entry into this safe is defined as opening the door or making a 2 in.² opening (compared to a 6 in.² opening for tool-resistant safes), entirely through the door or front face. This size opening is designed to resist a "fishing-type" burglary attack, in which a small hole is drilled in the safe and an attempt made to "fish" out the valuables. The safe is required to have a combination lock, complying with UL 768 of Group 1 or 1R; or UL 2058, Type 1.

7.7.2.6.4 The limitation in the protection afforded by this safe is that the steel walls of the safe are vulnerable to torch attack once the concrete cladding is removed. The safes with composite materials in the body provide better protection. The TRTL-30 safe provides only moderate burglary protection because of the lack of testing on the body of the safe.

7.7.2.7 Torch- and Tool-Resistant Safe — Class TRTL-15x6.

7.7.2.7.1 This is the lowest rated safe that provides six-sided protection from tool and torch attack. This safe provides better protection in the walls than safes with the TRTL-30 label. Besides the tools permitted for testing the TRTL-30 safes, UL also allows the use of impact tools (such as an impact hammer, which is very effective in penetrating concrete). Entry into this safe is defined as opening the door or making a 2 in.² opening entirely through the door or body. The safe is required to

weigh at least 750 lb (340 kg) and have a combination lock, complying with UL 768 of Group 1 or 1R; or UL 2058, Type 1.

7.7.2.7.2 Safes with this label are intended for the medium risk situation. The door and body of the safe are usually constructed of super-hard composites that resist both tool and torch attack. These safes usually are manufactured with an inner and outer steel shell, between which the composite material is poured and allowed to harden. The lock and boltwork will be quite sophisticated, with hard-alloy plates protecting not only the lock itself, but the boltwork as well. The bolts will usually be of a hardened steel alloy to resist torch and tool attacks.

7.7.2.8 Torch- and Tool-Resistant Safe - Class TRTL-30x6. Safes with this label are intended for high risk situations with substantial inventory levels. The construction of this safe is similar to that of the TRTL-15x6, except that it is required to provide twice the protection in terms of length of time. The tools used in the test are the same as that used on the TRTL-15x6, as well as the definition of entry. The safe is required to weigh at least 750 lb (340 kg) and have a combination lock, complying with UL 768 of Group 1 or 1R; or UL 2058, Type 1.

7.7.2.9 Torch- and Tool-Resistant Safe — Class TRTL-60x6. Prior to the introduction of the TRTL-30x6 in 1980, this was the lowest rated of the UL safes that provided six-sided protection, even though UL classified it as TRTL-60. With the publication of the 1995 edition of UL 687, the classification was changed to TRTL-60x6. This means that only safes manufactured after 1995 will bear the TRTL-60x6 label; all older safes will have the TRTL-60 label.

7.7.2.9.1 The same testing requirements and tool complement that apply to the TRTL-30x6 safe, apply to this safe. The safe is required to weigh at least 750 lb (340 kg) and have a combination lock, complying with UL 768 of Group 1 or 1R; or UL 2058, Type 1.

7.7.2.9.2 This safe finds application in high risk situations; however, because of its high cost, it has essentially been replaced by the TRTL-30x6 safe, which is less costly.

7.7.2.10 Torch-, Explosive- and Tool-Resistant Safe — Class TXTL-60x6. This safe also did not have the x6 designation until 1995, and so safes manufactured prior to 1995 will have a TXTL-60 label. This safe is intended for the very highest risks and is designed to offer six-sided protection against entry from explosives, torches, and tools for 60 minutes, with the explosive charge limited to 4 oz (113 g) of nitroglycerine or its equivalent. UL requires that the safe weigh at least 1000 lb (454 kg) and have a combination lock, complying with UL 768 of Group 1 or 1R; or UL 2058, Type 1.

7.7.3 Fire-Resistant Safes. There are three classes of fire-resistant safes. All three classes must pass three tests: fire endurance, explosion, and impact. During the fire endurance test, the inside temperature of a safe cannot exceed 350°F (176.7° C) at any time during the test. At the end of the test, all papers inside a safe must be entirely legible and uncharred.

7.7.3.1 Class 350-4 Hours. A safe containing papers and records is placed in a testing furnace, and the temperature is raised through a standard curve until it is 2000°F (1093°C) at the end of 4 hours.

7.7.3.2 Class 350-2 Hours. A specimen safe containing papers and records is placed in a testing furnace, must withstand 2 hours of exposure to heat reaching 1850°F (1010°C).

7.7.3.3 Class 350-1 Hour. A specimen safe containing papers and records is placed in a testing furnace for a 1-hour exposure to heat reaching 1700°F (927°C).

7.8 Insulated Filing Devices. Insulated filing devices afford considerably less protection for records than the three levels of fire-resistive containers discussed in 7.7.3. The thermocouple devices to measure interior heat during the tests are located in the center of the interior compartment, and the insulated filing devices are not drop tested. As it is possible to confuse the 350-1 Insulated Filing Device with the 350-1 Fire-Resistant Safe, the label should be carefully noted.

7.8.1 Class 350-1 Hour. A specimen filing device is placed in a testing furnace and is heated to temperatures reaching 1700°F (927°C), for 1 hour.

7.8.2 Class 350-½ Hour (Former UL and SMNA Classification “E”). A specimen filing device is heated for ½ hour to a temperature reaching 1550°F (843°C) in a test furnace.

7.9 Combination Locks for Safes and Vaults. These types of locks are classified by UL as Group 1, Group 1R, Group 2, or Group 2M according to the degree of protection afforded against unauthorized opening.

7.9.1 Group 1. Group 1 combination locks afford a choice of at least 1,000,000 combinations and are highly resistant to expert or professional manipulation for a period of 20 man-hours.

7.9.2 Group 1R. Group 1R combination locks afford a choice of at least 1,000,000 combinations and are highly resistant to expert manipulation. In addition to resisting unauthorized opening by expert manipulation, these locks are secure against radiological attack.

7.9.3 Group 2. Group 2 combination locks afford a choice of at least 1,000,000 combinations and have a moderate degree of resistance to unauthorized openings.

7.9.4 Group 2M. Group 2M combination locks afford a choice of at least 1,000,000 combinations and have 2 working hours of resistance to expert or professional manipulation. These combination locks are considered suitable for use on insulated safes, insulated record containers, insulated vault doors, light vault doors, and tamper-resistant doors.

7.10 Combinations Numbers.

7.10.1 Changing Combinations. Combinations to insulated and burglary-resistant containers should be changed by the responsible individual, the security officer, or by a bonded contractor. Combinations should be changed when the container is placed in use, when an individual knowing the combination no longer requires access to the container, when the combination has been lost or is suspected to have been lost, at least once every 12 months, or when the container is taken out of service. Combinations to containers taken out of service must be reset to the standard factory combination of 50-25-50 prior to removal from the office space.

7.10.2 Methods. Combination locks have either hand-change or key-change capability. A number of combination locks produced by a variety of manufacturers have been approved by GSA. These GSA approved locks along with the non-approved locks use slightly different operating instructions and unique keys or particular hand change techniques for changing combinations. Often the experience necessary, as well as change keys, operating instructions, and changing procedures are lost with the passing of time.