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APTA Transit Infrastructure and Systems Security Working Group

Fencing Systems to Control Access to Transit Facilities

Abstract: This recommended practice provides guidance for the installation of fencing systems to control access to areas under the jurisdiction of a transit agency.

Keywords: access control, analysis, assessment, CPTED, gate, landscaping, lighting, threat and vulnerability fencing systems

Summary: A fencing system is a component of access control systems. It defines boundaries and limits, channels access and egress, provides visual barriers, supports security and safety, and can deter and delay intrusion and trespassing. Many fencing systems are available to the public transportation industry, ranging from high-security grille type to cost-effective chain-link. Fencing systems should be integrated with other security standards and best practices, such as Crime Prevention Through Environmental Design, lighting, barriers and so on to provide protection and enhance other security solutions.

Scope and purpose: This document covers physical fencing systems only, and does not include virtual or other technology-driven fencing systems. Gate systems are covered in a dedicated recommended practice. This document is intended to ensure that security measures are employed in the design, material specification, installation and placement of fencing systems; that security considerations are incorporated during the design and building process; and that all pertinent stakeholders are identified in the process of selection and placement of fencing systems.

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Introduction

This introduction is not part of APTA SS-SIS-RP-003-10, "Fencing Systems to Control Access to Transit Facilities."

APTA recommends the use of this document by:

- individuals or organizations that operate rail transit systems;
- individuals or organizations that contract with others for the operation of rail transit systems; and
- individuals or organizations that influence how rail transit systems are operated (including but not limited to consultants, designers and contractors).

Fencing Systems to Control Access to Transit Facilities

1. Fencing systems purpose

To the extent possible, fencing systems should be designed to meet the specific needs of users of transit facilities, including in parking, walkways, and internal or underground areas. Installation of fencing systems should serve a purpose, be conducive to operations, and not become a financial or maintenance burden. System design should comply with local and community ordnances but also complement the Crime Prevention Through Environmental Design (CPTED) principle of natural surveillance, access control and territorial reinforcement in the appropriate environment. Fencing systems can provide the following benefits:

- Give notice of legal boundary of the outermost limits of a facility.
- Assist in controlling and channeling people into or along specific areas and deterring entry elsewhere along the boundary.
- Support surveillance, detection, assessment and other security functions by providing a zone to install intrusion detection and surveillance equipment.
- Create a psychological deterrent.
- Deter casual intruders from penetrating a secured area by presenting an obstacle that requires an overt action to climb over, under or through.
- Require intruders to make a clear action demonstrating their intent to gain entry.
- Cause a delay in access to a facility, thereby increasing the possibility of detection and apprehension.
- Reduce the staffing requirements at a site by optimizing the frequency and saturation of the patrol area.
- Provide a cost-effective method of protecting facilities.

Fencing system designs should be reviewed by the agency's security management to ensure current security industry best practices are being considered and applied. See Appendix A for a sample Fencing System Checklist to use when planning and designing fencing systems.

2. Security risk assessment considerations

Transit agencies should complete a current system-wide security risk assessment with recommendations to identify, evaluate and reduce risks to the system's people, assets, operations and infrastructure. Additional information about security risk assessments can be found in the APTA standard "Security Risk Assessment Methodology for Public Transit" (APTA SS-SIS-S-017-21).

2.1 Crime Prevention Through Environmental Design (CPTED)

Transit agencies should consider applying the CPTED principles of natural surveillance, natural access control, territorial reinforcement and maintenance to the design and planning of a fencing system. A CPTED survey may identify or recommend enhancements that can be employed as crime prevention or other security measures. Additional information about CPTED can be found in the APTA recommended practice "Crime Prevention Through Environmental Design (CPTED)" (APTA SS-SIS-RP-007-10).

3. Site environmental considerations

Many factors can impact fencing system installation, operations and maintenance. However, fencing system material construction, fencing height and installation method are key factors in fence selection. Transit agencies should strive to identify all factors when evaluating existing and designing proposed fencing systems. Site selection considerations should consider hazards as well as threats, including the following:

- Identify high water tables, retaining ponds and site grading plan drainage above and below ground, which may affect the material condition of fencing components or footings, or can affect drainage or result in debris buildup.
- Identify topography and analyze surface and subsurface soil components and other conditions to determine suitability and stability for fencing.
- Identify surface and subsurface utilities and other installations.
- Check local ordinances, covenants or agreements for restrictions or requirements that may affect fencing system type, style, color, height, etc.
- Determine impact to pedestrian/vehicle circulation, users, the community and the transit service.
- Identify frequency, location and targets of vandalism, which may influence the type, style or manufactured components of the fencing design.
- Identify perimeter boundary lines and footprint so as not to encroach on non–transit agency property. Determine the property's minimum footprint to establish a boundary that creates standoff distance and a clear zone.
- Identify load, wind or other ratings associated with area weather patterns, conditions or other hazardous conditions, such as wind and snow, seismic, wildfire, etc., that may damage or destroy fencing components or structure; weaken its strength or stability; or allow climbing, jumping or stepping over to penetrate the perimeter's boundary. For example, fallen trees on fencing or snow removal staging.
- Complete a CPTED survey of the property to identify natural access and surveillance, territorial reinforcement, crime prevention, and homeland security exposures and recommendations. Periodically review and update agency CPTED surveys to address changes in community trends or the surrounding environment.
- Complete a site survey of the property boundary to identify preexisting conditions, such as adjacent property clear zones, standoff distance, property encroachment, etc. Complete, review and update the site survey annually to address changes to the site or its surrounding conditions.
- Investigate and research to identify the locations of fencing systems located within close proximity to power lines, catenary wires and the third rail to determine the proper grounding of power systems.
- Identify possible interference of fencing materials with local communications (radio) networks.

The environment in which the fencing will be installed will influence the height, application and type of fencing system selected. For example, some fencing systems may be appropriate for a sidewalk or walkway, while more robust or reinforced fencing systems may be appropriate around the perimeter of critical infrastructure. The type of fencing system should be suitable to its application and environment. Local ordinances and code requirements should be reviewed during the design planning stages to determine if any fencing system requirements or restrictions apply.

3.1 Clear zones

Clear zones provide an unobstructed view of the fencing system to make it more difficult for potential intruders to approach or breach the fence unobserved. They also provide natural surveillance (a CPTED principle) for both sides of the fencing system. Where practical, the transit agency should identify and designate clear zones on the exterior and interior sides of its property's fencing system. Clear zones should be free of any objects or features that offer concealment or that could provide unauthorized access to the

property, such as overhanging tree limbs, utility poles, posts, etc. Vegetation in clear zones should be kept short to limit cover and concealment of potential intruders. It should be trimmed regularly to prevent overgrowth and maintain the clear zone area. If a clear zone is not practical, then other compensatory measures should be implemented to control access, such as a taller fencing system and controlled lighting, surveillance and detection systems, or security patrols.

3.2 Standoff distance

The most effective tool to keep threats from assets is standoff distance. In general, the more standoff distance provided, the more the risk is reduced. Standoff differs from clear zone distance in that there is no ideal standoff distance; it is determined by threat, type of construction and desired level of protection. Standoff distances can be incorporated into landscape and streetscape by benches, bollards, barriers or other types of barricade devices. Where practical, the maximum distances for standoff should be designated and access-controlled.

3.3 Fence electrification

Metal fences can be electrified based on proximity to energy sources. Where applicable, metal objects should be grounded in accordance with local codes and agency engineering guidelines.

4. Fencing system considerations

Fencing system material, construction, installation method and design are significant factors in selecting fencing systems.

4.1 Fencing system selection

Fencing systems are typically made of metal, aluminum or wood. Additionally, other materials, such as vinyl, plastics, composites and combined wood-metal-plastics-composites products are being introduced to the market. Some of these materials reduce maintenance, upkeep and repair, or they increase the life expectancy of the system. Every material has specific maintenance considerations that can impact the use and life expectancy of the system. If aesthetics are a priority, ornamental fencing systems can provide a low-profile appearance through reduced height or incorporation of colors, environmental coatings or lattice style inserts while maintaining anti-scaling capabilities.

Some fencing systems are designed and installed for temporary use, while others are installed for short- to long-term or even permanent use. A facility's security requirements may be best met by a combination of installation types, and this should be evaluated as part of the risk assessment and design process. There are as many installation methods as there are types of fencing system. The manufacturer's recommended installation methods should always be followed.

Materials left or piled near the fence (such as debris, vehicles or snow) may create vulnerabilities and should be discouraged. Intruders may use these materials to help them climb over a fencing system to enter or leave the property. Similarly, fencing adjacent to gates should be designed to prevent reaching through or use of tools between the pickets to open the gate.

Each type of fencing system has strengths and weaknesses, and factors unique to the site may create other impacts or enhancements. Regardless, the factors for each design should be carefully evaluated against each proposed fencing system prior to a final installation decision. Furthermore, the basis for installing a fencing system should be well-defined and included in any design plans implementing such physical security measures.

4.2 Fencing system protection

Fencing systems, gates and other components in proximity of moving vehicle traffic may be prone to damage from vehicles. However, damage to gates and fencing systems may be reduced by considering the site environment in the design process. Standoff distance, wider gate opening, and the installation of bollards or other heavy objects placed to withstand damaging impact are possible strategies to protect both gates and fencing systems. A project's design review before final approval and implementation is the best time to identify and rectify any issues that could result in gate and fencing system damage.

4.3 Signs

Signs may be posted on fences to further inform the public that access to a facility, its wayside substations and signal rooms, or its other infrastructure is restricted and unauthorized individuals are not permitted, and to warn of a danger, such as electrical hazard or moving trains. Warnings such as "No Trespassing," "Private Property," "Restricted Area," "Authorized Personnel Only," "Danger – Moving Trains," "Danger – Electrical Hazard," "Danger – High Voltage" and other appropriate signage may be used. When possible, signs depicting appropriate international symbols should be used in addition to written words. Signs should be installed in clear view and posted or attached to the fencing system materials at uniform intervals or every 100 ft to deter accidental or inadvertent entry. The signage language should meet all applicable federal requirements (such as Title VI and ADA requirements), as well as state and local laws and ordinances.

4.4 Alarms

A perimeter intrusion detection system (PIDS) may be used in combination with a security fence to detect and warn of intrusions. Sensors should be compatible with the type of fence material used. The need and type of sensors should be based on a threat and vulnerability analysis. Sensors should alarm to the transit agency's operations control center or security center. When selecting the right sensors, special consideration must be taken to evaluate the environmental factors. Environmental factors could play an important role in the nuisance alarm rates of the sensors selected for a PIDS. In many cases the use of dual sensors can drastically cut down on the nuisance alarm rates.

4.5 Gates

Gates serve to channel pedestrian and/or vehicle circulation to and from an area and are the only moveable part of a fencing system. For that reason, gates can increase or decrease the security requirements at a site and should be closed and locked when not in use. Measures to prevent hinges from being removed (e.g., peen bolts or loop and crimp wire rope around gate and fencing post) should be incorporated in all gate installations. A site vehicular and pedestrian circulation study, coupled with a site security risk assessment, should be completed to determine the number and locations of gates necessary for operations. Gates are manufactured in many variations (swing, slide, horizontal, vertical, etc.) to accommodate identified site requirements. Additional information about gates can be found in the APTA recommended practice "Gates to Control Access to Revenue and Nonrevenue Transit Facilities" (APTA SS-SIS-RP-005-10).

4.6 Anti-vehicle barriers

To enhance anti-vehicle physical security resistance, some fencing systems integrate anti-vehicle barriers into systems designed to control pedestrian access. Anti-vehicle barriers may be discreetly incorporated into the fencing system to present an aesthetically appealing look while affording a site with formidable anti-vehicle protection. A site security assessment should be completed to identify any requirement for this type of fencing system/barrier design. Additional information about anti-vehicle barriers can be found in the APTA recommended practice "Anti-Vehicle Barriers for Public Transit" (APTA SS-SIS-RP-009-12).

4.7 Inspection and maintenance

Fencing systems should be regularly inspected for integrity, functionality and signs of damage. Visual and hands-on inspections can provide the most complete assessment of a fencing system's overall condition. Maintenance should be performed according to the manufactured recommended schedule. Repairs, when necessary, should be completed promptly.

5. Fencing system elements

Various materials, components and hardware make up a fencing system. Most fencing systems contain some type of common element(s) and are designed under guiding industry practices. However, local ordinances should be checked and verified to ensure compliance with local or other agency requirements and practices.

5.1 Common fencing system elements

The following are common elements across most types of fencing systems:

- **Posts.** Fencing system posts should be as tall as the material they support; be of sufficient strength to hold the fencing materials in place; and be firmly set in the ground to prevent shifting by wind, erosion or other environmental conditions. The depth of fence post installation should be appropriate for the region and consider winter freeze–thaw cycles.
- **Material.** Fencing system materials (wood panels, plastic weave, metal diamond mesh, aluminum pales or pickets, etc.) should be securely fastened to posts and supporting hardware (bracing bars, rods, wire, etc.) to prevent sag, sway or removal. The smaller the mesh opening, the more difficult it would be to cut or use as a foothold or handhold. The closer the panels are fastened next to one another, the less opportunity there is for a person to fit between them to gain access through the opening. Horizontal and vertical fencing system rails should be secured in place to prevent removal.
- **Environmental coating.** Metal fencing systems exposed to various environmental conditions may be protected with a wide range of exterior coatings, including zinc (galvanized), aluminum, metallic or polyvinyl chloride coatings. The color of fence coatings should also be considered. Lighter-colored fencing materials, typically covered with polymer protection, allow objects, people and other assets seen through an ornamental fence to contrast with their environment. The contrasting effect to foreground or background colors (e.g., dark foreground to light background and vice versa) affords greater opportunities to observe and identify potential threats.
- **Hardware.** All hardware and components (nails, screws, nuts, bolts, hinges, bracing, rods, wire, etc.) should be installed on the inside of the fencing system when feasible and peen- or spot-welded in place to prevent removal.
- **Outriggers.** Single barbed-wire arms called outriggers may be installed and directed inward or outward of the property or in a vertical position. Double barbed-wire arms (forming a "V") can be installed on top of fencing posts and directed simultaneously inward and outward of the property. It is most difficult to scale a fence from the outward-leaning side of any outriggers.
- **Barbed wire.** Strands of barbed wire attached to arms at the top of or sides of fencing systems should be attached in strands of three or more.
- **Concertina wire (also referred to as "barbed tape" or "barbed concertina wire").** Attach unraveled and stretched coils to the top or to the sides of fencing systems or to strands of barbed wire that are installed to the top of fencing systems. However, coils installed at the ground level in single or multiple coils should be connected to the adjacent fencing systems and other coils of wire, and staked to the ground to prevent removal by humans or shifting by winds, erosion or other environmental conditions.
- **Razor tape (also referred to as "razor wire").** Attach unraveled and stretched coils to the top or sides of fencing systems or to the strands of barbed wire installed on the top of fencing systems. However, coils installed at the ground level in single or multiple coils should be connected to the

fencing systems and other coils of wire, and staked to the ground to prevent removal by humans or shifting by winds, erosion or other environmental conditions.

5.2 Ornamental fencing systems

Ornamental fencing systems are aesthetically designed fencing systems used as a physical security entry control measure. An ornamental fencing system is installed to control, channel or restrict entry or exit of personnel and/or equipment to a location or an area. Ornamental fencing systems are usually permanent and are either active or passive. These materials, plus the arrangement of pales of pickets, allow this type of fencing to be used in high-security applications. The most commonly used type of ornamental fencing employed in the transit system environment is described in **Table 1**.

TABLE 1
Ornamental Fencing Description and Use

Fencing Type	Description	Potential Uses
Metal or aluminum alloy fencing 	• Pickets vary based on application. • Posts are set in concrete, usually 10 ft (3.05 m) on-center apart. • Height varies based on application, but can range from 4 to 12 ft (1.21 to 3.65 m). • Pickets can be extended, shaped and curved for use and top guard. • Top-guard treatments (e.g., barbed wire and razor tape) may be installed at the top or bottom of the fencing. • Aircraft cabling can be attached to the fencing interior with anchored in-ground footings to reinforce resistance.	• Provide temporary or permanent perimeter definition around large or small facilities, buildings, restricted areas, walkways or parking lots. • Channel pedestrian circulation. • Prevent access to unauthorized areas. • Protect against vehicle ramming or penetration. • Provide effective delay or deterrents where necessary in a high-threat environment where aesthetics are important.

Though ornamental fencing systems can be manufactured of metal, plastic or wood, this recommended practice concentrates on ornamental systems made of various types of metal. Other materials, such as vinyl- and plastic-coated metal products, are being introduced by the fencing industry. These coating materials have demonstrated use in reducing maintenance, upkeep and repair, as well as extending life span, and should be considered in the final fencing selection. Each of the materials has specific maintenance issues and concerns that can impact the use and life expectancy of the system.

Additionally, some ornamental fencing is designed and installed for temporary use, while some is installed for long-term or permanent use. A combination of the types of installation that may best suit a facility or an area's specific security requirements should be carefully evaluated as part of the security risk assessment and design processes.

Table 2 identifies the strength, weakness, level of protection and average life span for metal or aluminum alloy ornamental fencing.

TABLE 2
Ornamental Fencing Strengths and Weaknesses

Fencing system	Strengths	Weaknesses	Level of Protection	Average Life
Metal or aluminum alloy fencing	• Low maintenance. • Aesthetic appearance. • Easily configurable by size or shape. • Vertical fencing pickets limit foothold or handgrip to scale over fencing. • Easily repaired. • Picket spacing can enhance natural surveillance. When visibility is not a requirement, narrow picket spacing should be considered to minimize climbing. • May require several cuts to develop an opening large enough for human penetration.	• Horizontal bracing may provide a foothold. • Medium to high cost. • May not be “off-the-shelf.” • May require specialized installation.	Medium	20 years

5.3 Chain-link, mesh or woven metal fencing systems

Chain-link, mesh or woven metal fencing systems are a physical security entry control measure installed to control, channel or restrict the entry or exit of personnel to a location or an area. Many styles of chain-link, mesh and woven metal fencing systems are available to the public transportation industry, ranging from very high-security expanded metal mesh to more conventional and cost-effective chain-link and woven metal fencing systems. Chain-link, mesh and woven fencing systems can be temporary or permanent and active or passive. The most commonly used types of chain-link, mesh and woven metal fencing systems employed in the transit system environment are described in **Table 3**.

TABLE 3
Chain-Link, Mesh or Woven Metal Fencing Description and Use

Fencing Type	Description	Potential Uses
Standard chain-link 	• Galvanized standard steel chain-link, mesh or woven metal fencing. • Mesh sizes vary based on application. • Posts are set in concrete, usually 10 ft (3.04 m) on-center apart. • Height varies based on application but can range from 4 to 12 ft (1.21 to 3.65 m). • Top-guard treatments (e.g., barbed wire and razor tape) may be installed at the top or bottom of the fencing.	• Provide temporary or permanent perimeter definition around large or small facilities, buildings, restricted areas, walkways, or parking lots. • Channel pedestrian circulation. • Prevent access to unauthorized areas.

TABLE 3

Chain-Link, Mesh or Woven Metal Fencing Description and Use

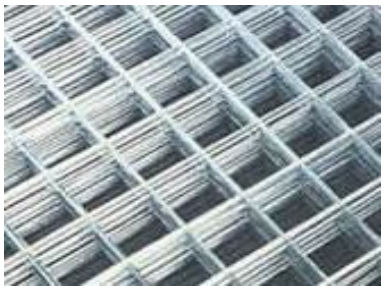
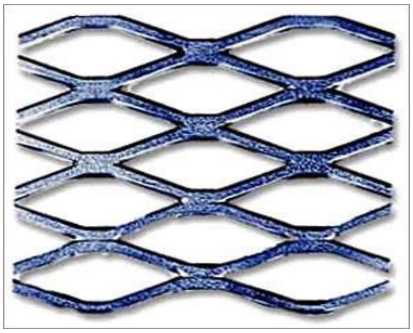
Fencing Type	Description	Potential Uses
Chain-link on walls 	• Galvanized standard steel chain-link, mesh or woven metal fencing systems installed on short "T" wall. • Fencing mesh may vary based on application as well as height. Height can vary, but application can determine height and range from 4 to 12 ft (1.21 to 3.65 m). • Posts are set in concrete, usually 10 ft (3.04 m) on-center apart. • Top-guard treatments (e.g., barbed wire and razor tape) may be installed at the top or bottom of the fencing.	• Combine a partial barrier with fencing. • Ensure a stable footing to limit damage to chain-link, mesh or woven metal fencing systems. • Provide permanent perimeter definition around large or small facilities, buildings, restricted areas, walkways or parking lots. • Channel pedestrian circulation. • Prevent access to unauthorized areas.
Woven metal wire mesh 	• Woven metal wire mesh is similar to chain-link but has varying sizes of mesh and different colors and coating. • Can be framed in metal panel and connected to posts set in concrete. • Mesh openings can vary from 1½ to 6 in. (38.1 to 152.4 mm) or larger in diameter.	• Provide temporary or permanent perimeter definition around large or small facilities, buildings, restricted areas, walkways, or parking lots. • Channel pedestrian circulation. • Prevent access to unauthorized areas.
Welded wire (panels) 	• Wire is welded at every joint or wire crossing. • The varied-size mesh is usually rectangular or square. • Mesh openings can be made too small to offer a toehold or handgrip; they can vary from 1½ to 6 in. (38.1 to 152.4 mm) or larger in diameter. • Welded wire mesh can be installed in framed metal panels and connected to posts set in concrete.	• Provide temporary or permanent perimeter definition around large or small facilities, buildings, restricted areas, walkways, or parking lots. • Channel pedestrian circulation. • Prevent access to unauthorized areas.
Expanded metal 	• Open diamond-shaped mesh is manufactured from 6- to 9-gauge metals. • Mesh opening varies from 0.02 to 8 in. (0.51 to 203.2 mm) in diameter. • Posts are spaced at 8 ft (2.44 m) on-center and are set in concrete. • Framed mesh panels are connected to posts. • Panel height can range from 6 to 15 ft (1.82 to 4.57 m) with a length of 8 ft (2.44 m). • Panels are coated against environmental conditions.	• Provide effective delay and deterrence where necessary in a high-threat environment. • Defeat scaling by all but the most determined adversaries. • Complement initial perimeter fence line or be used as a secondary fencing system boundary around high-security assets.

TABLE 3
Chain-Link, Mesh or Woven Metal Fencing Description and Use

Fencing Type	Description	Potential Uses
Temporary 	• Description varies with system. For example, metal or plastic chain-link, woven metal or mesh fabric panel fencing; fencing attached to top of concrete (jersey) barriers; coiled or stretched barbed wire; coiled or stretched razor wire, etc. • Temporary fencing systems can enclose an area by being placed on the ground (wire) or by interconnecting panels or sections ranging from 10 to 12 ft (3.05 to 3.66 m) long and 3 to 12 ft (0.91 to 3.66 m) high. • May include fence installed on top of barriers, footings, etc.	• Restrict or direct vehicle or foot traffic, demarcate an area, or create a buffer zone, for either short- or long-term temporary use, or for special events.
Temporary chain-link on barriers 	• Chain-link, mesh or woven metal fencing systems with barbed wire or razor tape attached to top of filled or concrete (jersey) barriers. • Temporary fencing systems can enclose an area by being placed on the ground (wire) or by interconnecting panels or sections ranging from 10 to 12 ft (3.05 to 3.66 m) long and 3 to 12 ft (0.91 to 3.66 m) high. • Filled barriers should utilize sand, water, antifreeze or other suitable contents.	• Restrict or direct vehicle or foot traffic, demarcate an area, or create a buffer zone, for either short- or long-term temporary use, or for special events.

Chain-link, mesh or woven metal fencing systems can be manufactured of steel or aluminum. Other materials such as vinyl- and plastic-coated metal products are being introduced to the fencing industry. These coating materials have demonstrated use in reducing maintenance, upkeep, repair, etc., as well as extending life span, and should be considered in the final fencing selection. Each of the materials has specific maintenance issues and concerns that can impact the use and life expectancy of the system.

Some chain-link, mesh or woven metal fencing systems are designed and installed for temporary use, while others are installed for long-term or permanent use. A combination of the types of installation that may best suit a facility or an area's specific security requirements should be carefully evaluated as part of the security risk assessment and design processes. Installation is critical to fencing systems design and selection, and there are as many installation methods as there are varieties of fencing materials. The manufacturer's recommended installation methods should always be followed.

Chain-link, mesh or woven metal fencing systems also include specific hardware components and manufacturing processes that ensure the stability and strength of the installed system. Several of these components are described below:

- **Tie wire.** Metal wire that attaches the fencing systems mesh to the bracing or posts. Tie wire is wrapped approximately 180 deg. around the bracing in order to secure the mesh.

- **Tension wire.** Wire horizontally interwoven throughout the top or bottom 6 in. (152.4 mm) of the fence fabric to provide rigidity to its top and bottom structures, if bracing rails are not installed.
- **Hog ring.** Applicable to woven metal fencing systems. A C-shaped wire clip that attaches the top or bottom tension wire to the chain-link fabric at horizontal intervals of approximately 2 ft (0.61 m).
- **Knuckle.** Applicable to chain-link fencing systems. The selvage (manufacturer's finish) obtained by interlocking pairs of wire ends and bending them back into a loop at the fabric edge. As an alternative, the selvage should be twisted and barbed at the top and bottom.

Table 4 identifies the strengths, weaknesses, level of protection, and average lifetime for different types of chain-link, mesh or woven metal fencing.

TABLE 4
Chain-Link, Mesh or Woven Metal Fencing Strengths and Weaknesses

Fencing system	Strengths	Weaknesses	Level of Protection	Average Life
Expanded metal	• Provides a strong physical and psychological barrier to all but the most determined adversaries. • Mesh is difficult to cut.	• High cost.	High	25+ years
Portable/ temporary	• Low-cost, rapid deployment easily configured for a wide variety of requirements. • Panels may be attached to concrete barriers or standalone.	• Offers limited protection and may require protective clothing to deploy. • Not permanently installed.	Low	10+ years
Temporary chain-link on barrier	• Low maintenance. • Maintenance is reduced with use of vinyl or composite design fencing. • Reinforced base structure; provides aesthetic appearance.	• High initial cost. • Fencing likely replaced before wall under normal conditions.	Medium	Wall: 15 years Fencing: 5+years
Permanent chain-link on barrier	• Permanent installation improves strength and security to infrastructure.	• High initial cost.	High	25+ years
Standard chain-link	• Low to medium cost. • Normally requires little to no maintenance • Easily configured to meet almost any size or shape requirements. • Readily available and easy to install with no specialized expertise.	• Easily cut with bolt cutters or strong shears. • Can be easily scaled, depending on height • Must be "framed" top, bottom and vertically at points along its length to provide adequate security.	Low	25+ years

TABLE 4
Chain-Link, Mesh or Woven Metal Fencing Strengths and Weaknesses

Fencing system	Strengths	Weaknesses	Level of Protection	Average Life
Chain-link on walls	• High cost for dual wall and fencing construction. • Normally requires little to no maintenance. • Easily configured to meet almost any size or shape requirements. • Fencing posts are embedded in solid material (e.g., concrete, stone or masonry) and may be more stable. • Reduced soil shifting. • Fencing height may be reduced to accommodate wall height to provide overall height.	• Easily cut with bolt cutters or strong shears. • Must be "framed" top, bottom and vertically at points along its length to provide adequate security. • Damage to either wall or fencing may result in damage to other component. • Wall can provide a foothold. • Can be easily scaled depending on height.	Medium	25+ years
Woven metal wire mesh	• Medium cost. • Normally requires little to no maintenance. • Easily configured to meet almost any size or shape requirements.	• Easily cut with bolt cutters or strong shears. • Can be easily scaled. • Must be "framed" top, bottom and vertically at points along its length to provide adequate security.	Low	25+ years
Welded wire	• Normally requires little to no maintenance. • Easily configured to meet almost any size or shape requirements.	• Medium to higher cost. • While easily cut with bolt cutters or strong shears, it requires many cuts to develop an opening. • Must be "framed" top, bottom and vertically at points along its length to provide adequate security.	Low	25+ years

6. Security best practices for fencing systems

Transit system security awareness and the implementation of best practices can affect a transit agency's overall security posture. Several examples of transit security fencing system best practices are listed in this section.

6.1 Security best practices for most fencing systems

The below best practices may be used across most types of fencing systems:

- **Install top guard.** May be considered depending on the results of the transit agency's security risk assessment.
- **Eliminate the top rail.** Omitting the top rail eliminates a handhold, making the fence more difficult to climb. An alternative to installing a top rail could be the installation of a taut 7-gauge coil spring wire.
- **Bolt or rivet barbed wire arm.** Secure the barbed wire arm to the post by bolt or rivet to prevent its removal.
- **Add barbed tape to barbed wire.** This added fence-top configuration increases the difficulty of scaling fencing systems, increasing the intruder's delay.
- **Eliminate enablers.** Boxes or other materials stacked against or in close proximity to perimeter barriers enable intruders to climb over a fencing system. Remove vegetation, objects, debris and material that could be used to breach a fencing system or hide intruders.

- **Control perimeter openings.** Address openings in the perimeter that allow uncontrolled access (culverts, ditches, etc.) These openings should be secured to a degree equivalent with the perimeter boundary.
- **Address water boundary/perimeter.** If a body of water forms any part of the perimeter, additional security measures to restrict access should be provided.
- **Bury the mesh material.** Burying the mesh material approximately 12 in. (305 mm) deep can deter penetration under the chain-link, mesh and woven fencing system's perimeter. As an alternative, pour a concrete "apron" of at least 6 in. (152 mm) at the bottom of the mesh fabric to fill any gaps between the ground and the bottom of the mesh.
- **Analyze contrast.** Designing color contrast into fencing system components can increase or decrease the natural surveillance of installed fencing system fabric. For instance, dark foreground colors against light background colors enhance the ability to see the details of activity along a perimeter fence line, whereas light foreground colors against dark backgrounds can have the same effect of enhancing view. However, the contrast afforded by dark- or light-colored fencing system components can be limited if they are not adequately analyzed against color patterns or treatments, as well as the changing seasons. Therefore, an analysis of the tones, patterns and canopy colors common in the area should be completed and the results understood before implementing and committing to a specific color/design/pattern.
- **Prevent hardware component removal.** Peen or spot-weld all nuts to bolts. This action reduces the potential removal of nuts and bolts.
- **Add secondary fencing around critical infrastructure.** Install a second fencing system to increase security around identified critical infrastructure, as identified through a security risk assessment. The second fence should be placed sufficiently apart from the primary fence so as not to enable climbing/jumping from one to the other. The secondary fence adds an element of deterrence and better enables detection.
- **Address culverts, troughs and drainage ditches.** Openings greater than 96 $in.^2$ (2.44 m^2) should be protected by chain-link, mesh or woven fencing systems. The protection may consist of iron grille mesh or other barrier devices designed to prevent unauthorized access but should not impede the flow of drainage. Hinged grille mesh that may be opened should incorporate high-security hasps, shackle and padlock, etc.
- **Use a Fencing System Checklist.** Appendix A provides a sample checklist that offers additional guidance and information for planning and designing fencing systems.

6.2 Security best practices for ornamental fencing systems

The below best practices are commonly applied to ornamental fencing systems:

- **Space pickets adequately.** Pickets, sometimes referred to as pales, should be spaced with consideration for vulnerability to climbing or penetration. Check local codes. Authorities often mandate maximum picket spacing distance. Pickets should be securely fastened to the exterior side of posts and supporting hardware (bracing bars, rods, wire, etc.) to prevent gaps, misalignments, sway or removal.
- **Bury the pickets.** Burying the pickets approximately 12 in. deep in solid ground can prevent penetration from under the ornamental fence's perimeter. As an alternative, pour a concrete "apron" of at least 6 in. at the bottom of the pickets.
- **Add bracing.** Top, middle or bottom bracing rails may be necessary to reinforce a fencing system's structural integrity between posts or at corners, to secure pickets and mesh materials firmly, or to enhance fencing system security. Bracing should always be installed on the inward side of the fencing systems. Note that excessive bracing can also facilitate climbing and should be used only when necessary. When vehicle crash resistance is required, fencing should be structurally designed to

withstand specific vehicle weight and speed criteria. This may involve concrete retaining walls or other barriers beneath the fencing.

6.3 Security best practices for chain-link, mesh or woven metal fencing systems

The below best practices are commonly applied to chain-link, mesh or woven metal fencing systems:

- **Install a bottom rail.** To prevent penetration of a boundary from under the fencing systems by pulling up the bottom edge of the material, install a bottom rail not less than 2 in. (50.8 mm) from the edge of the mesh material to solid ground. Minimize clearance between bottom of fencing material and the ground. Security fencing should consider treatment or hardening of surface grade material beneath the fence to prevent digging for access.
- **Adjust the mesh.** The mesh diamond pattern should not be larger than 2 in. (50.8 m) on a side. The smaller the mesh opening, the longer it would take to cut and the more difficult it would be to attain a foothold or handgrip for climbing. The heavier the mesh metal wire gauge, the more difficult it is to cut. Further, mesh should be securely fastened to the exterior side of posts and supporting hardware (bracing bars, rods, wire, etc.) to prevent sag, sway or removal. Other enhancements may include increasing overall mesh height, decreasing mesh weave diameter (size), increasing mesh gauge or upgrading or installing additional reinforcement hardware, etc. **Table 5** provides mesh size and gauge guidance based on security level.

TABLE 5

Security Level, Size and Gauge for Chain-Link, Mesh or Woven Metal Fencing Systems

Security Level	Mesh Opening Size		Mesh Wire Gauge
	in.	mm	
Extremely high security	⅜	9.52	11
Very high security	1	25.40	9
High security	1	25.40	11
Greater than normal security	2	50.80	6
Normal transit security	2	50.80	9

Related APTA standards

APTA SS-SIS-RP-007-10, "Crime Prevention Through Environmental Design (CPTED)"
APTA SS-SIS-S-017-21, "Security Risk Assessment Methodology for Public Transit"
APTA SS-SIS-RP-005-10, "Gates to Control Access to Revenue and Nonrevenue Transit Facilities"
APTA SS-SIS-RP-009-12, "Anti-Vehicle Barriers for Public Transit"

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Definitions

asset: Any real or personal property, tangible or intangible, that a company or individual owns that can be assigned a monetary value.

barbed wire: Twisted wires armed with barbs or sharp points. Also called barbwire.

clear zone: An area surrounding the perimeter of a facility that is free of shrubs and trees and features well-maintained landscaping that does not provide hiding places for an adversary.

Crime Prevention Through Environmental Design: The broad study and design of environments to encourage functionality and decrease antisocial behavior.

critical infrastructure: The fixed physical assets critical to the operations of a transit agency.

chain-link, mesh and woven fencing systems: A physical security entry control measure. They are installed to control, channel or restrict the entry or exit of personnel to a location or an area. Chain-link, mesh and woven fencing systems can be temporary or permanent, active or passive.

diamond pattern: The opening formed in chain-link mesh wire fencing fabric during its manufacture.

fencing system: A physical security entry control measure installed to control, channel or restrict entry or exit of personnel and equipment to a location or an area. Fencing systems can be temporary or permanent, active or passive.

gate system: The only moveable components of a fencing system. The gate components control, permit, channel or restrict entry and access to an area. Components may include the frame, top guard, fabric, hinges, latches, operators, locking devices, etc.

gauge: The thickness of the steel wire or metal material used in the manufacture of metal fence mesh.

mesh: The open pattern on a panel of fencing fabric.

natural access control: The physical guidance of people and equipment coming and going from a space by the placement of entrances, exits, fencing systems, landscaping and lighting. See *natural surveillance* and *territorial reinforcement*.

natural surveillance: The placement of physical features, activities and people in a way that maximizes visibility. See also *natural access control* and *territorial reinforcement*.

nonrevenue transit facility: A facility in which public access is restricted. Nonrevenue facilities include, but are not limited to, Operations Control Centers, maintenance facilities, bus vehicle storage yards, rail vehicle storage yards, traction power substations, communication rooms, train control rooms, emergency fan plants, elevator rooms, passenger station ancillary rooms, and other similar facilities.

ornamental fencing system: An aesthetically designed fencing system used as a physical security entry control measure. It is installed to control, channel or restrict the entry or exit of personnel and or equipment to a location or an area. Ornamental fencing systems are usually permanent and are either active or passive. Ornamental fencing is manufactured with tubular steel, aluminum or a combination of alloys. These materials, plus the arrangement of pales or pickets, allow this type of fencing to be used in high-security applications.

outrigger: A single metal brace installed at an angle designed to hold barbed or other type wires or coils in place at the top of a fencing system and/or gates. Double outriggers (forming a V) may be installed at the top of a fencing system.

panel: Fencing fabric of various opened or closed patterns and/or designs, manufactured in sections to be attached to posts.

pattern: The opening formed in mesh wire fencing fabric during its manufacture.

peen: To strike a piece of metal with a hammer, denting the surface, or mashing the threads of a bolt after installing a nut, to prevent the nut from being removed.

rail: Horizontal fencing system component connected or attached to anchored posts at each end of the rail. Rails can be manufactured of metal, plastic, composite or wooden materials.

razor tape: a mesh of metal strips with sharp edges whose purpose is to prevent passage by humans.

risk assessment: A formal, methodical process used to evaluate risks to a transit system. The security portion of the risk assessment identifies security threats (both terrorism and crime) to the transit system; evaluates system vulnerabilities to those threats; and determines the consequences to people, equipment and property.

revenue transit facility: A publicly accessible transit facility, or the publicly accessible portion of a mixed revenue/nonrevenue facility. Includes passenger stations and terminals, etc.

spot-welding: A means of preventing the physical removal or disassembly of chain-link, mesh and woven fencing system hardware and components. For instance, spot-welding a nut to its bolt prevents removal.

selvage: The manufacturer's finish to the top and the bottom of a fabric.

standoff: The distance maintained between an asset or portion thereof and the potential location for an explosive detonation or other threat.

station: A type of public transportation passenger facility designated for the purpose of boarding and deboarding passengers. Station features and amenities may include information/waiting areas, boarding and alighting platforms, ticket/fare card sales, turnstiles or other fare collection equipment, restrooms, concourses, mezzanines, vendor shops, and other related facilities.

transit agency: The organization that operates transit service and other related transportation services.

territorial reinforcement: The use of physical attributes that express ownership, such as fences, signage, landscaping, lighting, pavement designs, etc. See *natural access control* and *natural surveillance*.

top guard: Additional protection that is placed at the top of a fence to prevent jumping or climbing. Examples of top guards include barbed wire, concertina wire and razor tape.

Abbreviations and acronyms

ADA	Americans with Disabilities Act
CPTED	Crime Prevention Through Environmental Design
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PIDS	perimeter intrusion detection system

Summary of document changes

- Combines the following three previously independent recommended practices: "Fencing Systems to Control Access to Transit Facilities" (APTA-SS-SIS-RP-003-10, 2009), "Chain Link, Mesh, or Woven Metal Fencing Systems to Control Access" (APTA-SS-SIS-RP-004-10, 2010), and "Ornamental Fencing Systems to Control Access at Transit Facilities" (APTA-SS-SIS-RP-006-10, 2010)

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First published	—	—	—	—	Oct. 1, 2009
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Appendix A: Fencing System Checklist

The checklist below can be used to help identify selection criteria and determine design, location and installation of a fencing system for access control.

Fencing System Checklist	
Conducted by:	Date:
1. Has a transit facility risk assessment of the property/facility been completed? □ Yes, it was completed by _____. □ No, but it will be completed by _____.	
2. If so, are there actions pending on the assessment findings? What are they?	
3. Identify the primary purpose for a new or refurbished fencing system.	
4. Does a local jurisdiction direct any fencing system restrictions or prohibitions (height, type, color, style, etc.)?	
5. Is there an organizational, community or local ordnance requirement for the fence to be aesthetically pleasing?	
6. Does the fencing system meet the transit agency's established security design requirements?	
7. Have the appropriate safety factors (OSHA, NFPA, ADA, state, local ordinance, code, etc.) been considered in preparation for the fencing system?	
8. Will the fence line have any breaks?	
9. Are there any obstructions in the clear zone? Does the fence obstruct the right-of-way?	
10. List the standoff distance available on both sides of the fencing system.	
11. Does the fencing system require grounding?	

12. Will a review be performed to ensure that best practices, value and operational functionality are incorporated into the fencing system's final selection, design and installation?
13. Are the selected fencing system materials and components designed to resist corrosion or other environmental effects?
14. Will the selected fencing system design function appropriately under extreme environmental conditions?
15. Will the designed fencing system contrast or blend with the topography or geography of the site?
16. Will the security design include peening, spot-welding or damaging exposed threads, bolts and nuts to prevent removal of hardware?
17. Are culverts, drains and pipes that enter the property protected against unauthorized access?
18. Who will regularly inspect the fencing system for damage, maintenance or operations? When was the last inspection completed?
19. Is the fencing system subject to vehicle damage, either intentional or unintentional?
20. How will fencing system damage or inoperable components be reported and repaired?
21. Will regularly scheduled maintenance be performed in-house or by a contractor?
22. Has a property site survey been completed to identify natural and human-made preexisting conditions, such as adjacent property clear zones, standoff distance, property encroachment, etc.?
Comments: