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RECOMMENDED PRACTICE
American Public Transportation Association
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APTA Transit Infrastructure Security Work Group

Chain Link, Mesh, or Woven Metal Fencing Systems to Control Access at Transit Facilities

Abstract: This *Recommended Practice* provides guidance for chain link, mesh and woven metal fencing systems used to control access at revenue and nonrevenue transit facilities.

Keywords: access control, analysis, assessment, chain link, crime prevention through environmental design (CPTED), fencing systems, gate, landscaping, lighting, mesh, security, threat and vulnerability, woven metal

Summary: Chain link, mesh and woven metal fencing systems are components of access control systems. They define boundaries, channel access and egress, provide visual barriers, support security and safety, and deter and delay intrusion and trespassing. 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.

Scope and purpose: This document provides guidance in achieving access control objectives through the effective design and placement of chain link, mesh and woven metal fencing systems for revenue and nonrevenue transit facilities. It should be noted that this document specifically concentrates on metal materials due to the efficiency and security value of these materials. Other materials may be considered, but they are not addressed in this document. This *Recommended Practice* is intended to provide guidance that appropriate security measures are considered and employed in the design, specification, installation and maintenance of such fencing systems; incorporate security considerations during the design and building process; and identify all pertinent stakeholders in the process of selection and placement of such fencing systems. This document supplements the *Recommended Practice* "Master Fencing Systems to Control Access at Revenue and Nonrevenue Transit Facilities," which should be reviewed and considered when researching and developing fencing system practices for transit agencies. These recommended practices should be considered as components of a "systems approach" to achieving security-related objectives.

Participants

The American Public Transportation Association greatly appreciates the contributions of the **Transit Infrastructure Security Work Group**, which provided the primary effort in the drafting of this *Recommended Practice*.

At the time this standard was completed, the working group included the following members:

Sean Ryan, MNR, Chair
Bill Pitard, PB Americas
John Plante, CTA
April Panzer, MNR
Brian Taylor, Halifax
Charles Rappleyea, CATS
Gardner Tabon, Valley Metro
Harry Saporta, Good Harbor Consulting
Rick Gerhart, FTA
Jane Bass, TSA
David Hahn, APTA
Randy Clark, MBTA
Gabriela Amezcua, CTA
Allen Smith, SPAWRK
Mark Mahaffey, VTA
Robert Hertan, TSSI

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1. Stakeholder considerations

Chain link, mesh and woven metal fencing systems should be designed to meet the needs of each specific application (i.e., parking, walkways, internal or underground areas) for revenue and nonrevenue facilities. To the extent possible, the installation of chain link, mesh and woven metal fencing systems should serve a clear purpose, should be conducive to or at least not interfere with transit operations, and should present a minimal and manageable financial and maintenance burden. Additional information about incorporating fencing systems with barricade systems can be found in "Master Fencing Systems to Control Access at Revenue and Nonrevenue Transit Facilities," which should be reviewed.

1.1 Risk assessment considerations

Transit agencies should formally evaluate risk and use systemwide and asset-specific risk assessments as guides in determining effective placement of chain link, mesh and woven metal fencing systems to optimize security. This standard is intended to be incorporated with the application of anti-personnel fencing and not anti-vehicle fencing. For additional information, see the APTA *Recommended Practice* on risk assessment.

1.2 CPTED considerations

Transit agencies should complete a CPTED survey of the proposed fencing system installation site to identify exposures and recommend enhancements that can be employed as crime prevention or other security measures. For additional information, see the APTA *Recommended Practice* on CPTED.

1.3 Site considerations

Transportation agencies should identify installation, operations and maintenance factors when evaluating existing or planning new chain link, mesh or woven metal fencing systems.

If aesthetics are a priority, chain link, mesh or woven metal fencing systems may be designed with a low-profile appearance through reduced height or the incorporation of colors, environmental coatings or lattice-style inserts while maintaining anti-scaling capabilities. Chain link, mesh and woven metal fencing systems should be integrated with other security measures, including CPTED, lighting, barriers, etc., to optimize protection and complement security solutions. Chain link, mesh and woven metal fencing systems can also be used with protective vehicle barriers, but both should blend with area aesthetics and adhere to local ordinances.

For additional information, see "Master Fencing Systems to Control Access at Revenue and Nonrevenue Transit Facilities."

2. Types of chain link, mesh and woven metal fencing systems

Chain link, mesh and woven metal fencing system materials, construction, installation methods and designs are significant factors to determining fencing system selection. The most commonly used types of chain link, mesh and woven metal fencing systems employed in the transit system environment are described in **Table 1**. The table provides the type and description of fencing systems, as well as the potential use of each type in the transit environment.

TABLE 1
Fencing System Type, Description and Use

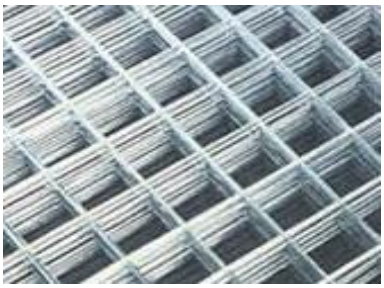
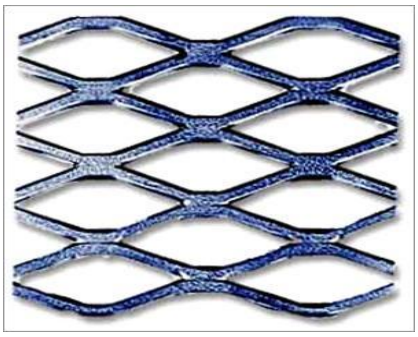
Fencing Type	Description	Potential Uses
Standard chain link 	• Galvanized standard steel chain link, mesh or woven metal fencing. • Mesh sizes vary based on application. • Posts are set in concrete, usually 10 ft (3.04 m) on-center apart. • Height varies based on application but can range from 4 to 12 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.	• To provide temporary or permanent perimeter definition around large or small facilities, buildings, restricted areas, walkways or parking lots. • To channel pedestrian circulation. • To prevent access to unauthorized areas.
Chain link on walls 	• Galvanized standard steel chain link, mesh, or woven metal fencing systems install on short “T” wall. • Fencing mesh may vary based on application as well as height. Height can range , 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.	• To combine a partial barrier with fencing. • To ensure a stable footing or to limit damage to chain link, mesh or woven metal fencing systems. • To provide permanent perimeter definition around large or small facilities, buildings, restricted areas, walkways or parking lots. • To channel pedestrian circulation. • To 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.	• To provide temporary or permanent perimeter definition around large or small facilities, buildings, restricted areas, walkways or parking lots. • To channel pedestrian circulation. • To 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.	• To provide temporary or permanent perimeter definition around large or small facilities, buildings, restricted areas, walkways or parking lots. • To channel pedestrian circulation. • To prevent access to unauthorized areas.

TABLE 1
Fencing System Type, Description and Use

Fencing Type	Description	Potential Uses
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. • Post 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.	• To provide effective delay and deterrence where necessary in a high-threat environment. • To defeat scaling by all but the most determined adversaries. • To complement initial perimeter fence line or be used as a secondary fencing system boundary around high-security assets.
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.	• To 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.	• To 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 cycle, 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. Manufacturers' recommended installation methods should always be followed.

Table 2 identifies the suggested uses, strength and weakness and level of protection provided for different types of fencing discussed in this *Recommended Practice*.

TABLE 2
Strengths and Weaknesses of Fencing Types

Fencing system	Strengths	Weaknesses	Level of Protection	Average Life
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
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

TABLE 2
Strengths and Weaknesses of Fencing Types

Fencing system	Strengths	Weaknesses	Level of Protection	Average Life
Expanded metal	• Provides a strong physical and psychological barrier to all but the most determined adversary. • 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 stand-alone.	• 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

3. Applications of chain link, mesh or woven metal fencing systems

Height, application and type are important to the environment of a chain link, mesh or woven metal fencing system. For example, where a 4 ft (1.22 m) chain link, mesh or woven metal fencing system may be appropriate for a sidewalk or walkway, a 12 ft (3.66 m) chain link, mesh or woven metal fencing system with barbed wire installed along the top may be equally appropriate around critical infrastructure, a perimeter boundary, etc.

The type of fencing system should be suitable to the application and environment. Local ordinances and code requirements should be reviewed during the planning and early design stages to determine if any chain link, mesh or woven metal fencing systems requirements or restrictions apply or exist.

3.1 Clear zones

Clear zones provide an unobstructed view of the fencing system to make it more difficult for potential intruders to be concealed from observation. Where practical, transit agencies should identify and designate clear zones on the exterior and interior sides of their property's fencing system.

3.2 Standoff distance

An effective tactic to keep threats away from assets is the use of standoff distance. In general, the more standoff distance provided, the more the risk is reduced.

3.3 Fencing system protection

Fencing systems and their components in the proximity of moving vehicle traffic may be prone to damage from bumping, hitting or by vehicles otherwise driving into or through them.

3.3.1 Vehicle barriers

To enhance anti-vehicle physical security resistance, some fencing systems integrate anti-vehicle barriers into systems designed to control pedestrian access.

3.3.2 Signs

The language of the signage should meet all applicable federal, state and local laws and ordinances.

3.4 Inspection and maintenance

Fencing systems should be regularly and systematically inspected for integrity, functionality and signs of damage.

4. Fencing system elements

Various materials, components and hardware make up fencing systems. Most fencing systems contain some types of common element(s) and are designed using standardized industry practices. Commonly designed fencing systems elements and industry practices are listed below:

- **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 a chain link, mesh or woven metal fencing system 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.
- **Height.** Fencing system mesh should be at least the height of the posts supporting it. Mesh installed in a security environment should always be higher than its supporting posts.
- **Posts.** Fencing system posts should be as tall or nearly 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 should consider the winter freeze and thaw cycles.
- **Bracing.** Top, middle or bottom bracing rails may be necessary to reinforce a chain link, mesh or woven metal fencing system's structural integrity between posts or at corners, to firmly secure mesh materials, or to enhance fencing system security. Bracing should always be installed on the inward side of the fencing system. When vehicle crash resistance is a requirement, 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. Note that excessive bracing can also facilitate climbing and should be used only when necessary.
- **Mesh.** The mesh diamond pattern should not be larger than 2 in. (50.80 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 (e.g., bracing bars, rods, wire, etc.) to prevent sag, sway or 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, 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 to the 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, other coils of wire, and staked to the ground to prevent removal by humans or shifting by winds, erosion or other environmental conditions.
- **Hardware.** Install all hardware and components (screws, nuts, bolts, hinges, bracing, rods, wire, etc.) to the interior side of the fencing systems and peen or spot-weld them in place to prevent removal.

Fencing systems include processes that are functions of the finished design (e.g., knuckle). Furthermore, fencing systems use specific connection components to 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 degrees around the bracing in order to secure the mesh. Applications: chain link, mesh or woven metal fencing systems.
- **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. Applications: chain link, mesh or woven metal fencing systems.
- **Hog ring.** 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). Application: woven metal fencing systems.
- **Knuckle.** 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. Application: chain link fencing systems.

5. Security

5.1 Mesh and gauge

Redundant, additional, or more durable components may be used to enhance security applications. Enhancements may include increasing overall mesh height, decreasing mesh weave diameter (size), increasing mesh gauge or upgrading or installing additional reinforcement hardware, etc. **Table 3** provides security enhancement guidance for mesh material that may further deter and delay fencing system penetration.

TABLE 3
Security Level, Size and Gauge

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

5.2 Security best practices

Transit systems security awareness and the implementation of best practices affect a transit agency's overall security posture. The following are examples of transit system security best practices specific to chain link, mesh or woven metal fencing systems.

- **Adjust the mesh:** Reduce the diamond or opening size of the mesh fabric and increase the metal gauge to make the fence more difficult to climb.
- **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.
- **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 fence to prevent digging for access.
- **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, thereby increasing the intruder's delay.

6. Further information

Appendix B of "Master Fencing Systems to Control Access to Revenue and Nonrevenue Transit Facilities" provides a system-specific checklist to provide users with guidance and information for planning and designing chain link, mesh, or woven metal fencing systems.

References

American Public Transportation Association, *Recommended Practice,* "Master Fencing Systems to Control Access at Revenue and Nonrevenue Transit Facilities," 2010. APTA SS-SIS-SS-003-10

ASTM International, *Standard Guide for Design and Construction of Chain Link Security Fencing*, ASTM F 2611-06, 2006. http://astm.nufu.eu/std/ASTM+F2611+-+06

Definitions

Definitions associated with chain link, mesh or woven metal wire fencing systems are incorporated into the APTA *Recommended Practice* "Master Fencing Systems to Control Access at Revenue and Nonrevenue Transit Facilities," as referenced above.

Abbreviations and acronyms

CPTED crime prevention through environmental design

