FRPR FRONT RANGE PASSENGER RAIL

SYSTEM DESIGN CRITERIA

COLORADO FRONT RANGE PASSENGER RAIL SYSTEM

- PRELIMINARY -

NOT FOR CONSTRUCTION

0. CONTENTS

0.1 AUTHORITY

These FRPR System Design Criteria and Engineering Standards present general guidelines and specific criteria to be used in the planning, design, and construction of passenger rail corridors for the Front Range Passenger Rail system. These System Design Criteria comply with safety and security requirements and are compatible with the intended future systems that FRPR will construct. The Engineering Standards reference and require the use of the most current accepted industry practices and applicable codes.

This manual establishes guidelines, criteria and standards to be used in the planning, design and construction process. Any deviation from these accepted criteria must be approved by FRPR Engineering as specified herein. Coordination with local agencies and jurisdictions is required to determine and approve fire protection, life safety and security measures that will be implemented as part of the planning, design and construction of the FRPR system. Conflicting information or directives within the criteria set forth in this Manual shall be brought to the attention of FRPR and will be addressed and resolved between FRPR and the local agencies and/or jurisdictions.

This initial version of the FRPR Design Criteria was published in winter of 2020. This version represents the first version of the Criteria, and any updates or modifications to the Criteria shall take precedence over previous versions or sections.

Version No.	Date of Revision	Revision By:	Change Summary
0.0	11/5/2020	Enright, Chris	Original Document

Approved by:

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1. GENERAL

1.1 PURPOSE

The Design Criteria (this document) establishes uniform and minimum standards for the planning, design, construction and maintenance of the Front Range Passenger Rail system and its facilities. This document is developed using industry best practices and standards from commuter and Class 1 railroads, with the intent to meet or exceed all regulatory requirements both from the State and Federal levels.

The Design Criteria is intended to cover the majority of FRPR's current and future design and construction needs. Subsequent major projects (such as system electrification) shall develop their own standards and criteria. Other local transit and rail agencies exist in parallel with the FRPR system, and integration (as possible) is intended with these agencies, to maximize the potential for the transit systems of the greater Front Range.

1.2 PROJECT GOALS

Vision: Developing passenger rail that serves Front Range communities from Fort Collins to Pueblo is a critical component of Colorado's future. FRPR will provide a safe, efficient, and reliable transportation option for travel between major population centers and destinations along the Front Range and create a backbone for connecting and expanding rail and transit options in the state and region.

The project would provide sustainable and reliable travel options to meet the growing needs of the state, supporting multiple transportation, economic, and environmental goals.

The Front Range Passenger Rail team is committed to a transparent and fully collaborative approach with the public, interest groups, and local jurisdictions. This effort is aimed at moving Front Range Passenger Rail from vision to implementation in support of sustainable, alternative mobility options for the growing Front Range.

1.3 DESIGN CRITERIA OVERVIEW

This document stands alongside with the Standard Drawings to collectively form the Engineering Standards of the Front Range Passenger Rail system. These are intended to be supplemented with more specific guidance and design standards in areas such as structures, shoring, and drafting/detailing as the project advances.

Design is to be directed toward minimum feasible costs for design, construction, capital facilities and operation; minimum energy consumption and minimum disruption of local businesses and communities. It should be consistent with system reliability, passenger comfort, mode of operation, type of rolling stock to be used and maintained. Safety for passengers, workers and the public is of primary importance.

1.3.1 ORDER OF PRECEDENCE

In the event of conflict between the Design Criteria, Standard Drawings, and regulations or industry standards, the most stringent requirements shall take precedence. In questions of generalized design where no specific regulation or industry standard applies, engineering judgement shall be applied, with the rationale and conflict presented to FRPR engineering leadership for approval.

Specific attention should be given to the Americans with Disabilities Act (ADA), the ADA Accessibility Guidelines for Building and Facilities (ADAAG), the ADA Accessibility Guidelines for Transportation Vehicles and to any succeeding modifications that may be issued. The applicability of those documents is noted in several sections of this manual where it appears to be particularly appropriate. However, the regulations must be adhered to in all areas, whether or not mentioned herein

1.3.2 DESIGN CODES AND MANUALS

In addition to this Design Criteria, the Engineer must comply with all other applicable engineering codes and standards, including those of the various Federal, State, and local jurisdictions.

If codes and/or manuals are specified herein for the design of an element of the FRPR system, then the most recent edition(s) shall be used. Responsibility for design remains with the Engineer in accordance with the terms and conditions of their contract with FRPR.

Where design codes conflict with each other, the Engineer shall notify FRPR in writing and recommend a solution. The Design Engineer shall also investigate those codes and manuals that have precedence.

Specific codes and standards include, but are not limited to, the following (latest editions):

- Americans with Disabilities Act
- Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)
- Americans with Disabilities Act Accessibility Guidelines for Transportation Vehicles
- Colorado Department of Transportation (CDOT) - Standard Specifications for Road and Bridge Construction
- CDOT M & S Standard Plans
- CDOT Roadway Design Guide
- FHWA Manual on Uniform Traffic Control Devices (MUTCD)
- Colorado Public Utilities Commission (PUC) Rules and Regulations
- International Fire Code
- International Building Code

- National Fire Protection Association (NFPA) Standard 130
- NFPA 101
- American Association of State Highway and Transportation Officials (AASHTO) - Standard Specifications for Highway Bridges
- AASHTO - Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals
- Regional Transportation District (RTD) Commuter Rail Design Criteria Manual
- National Railroad Passenger Corporation (Amtrak) Design Standards
- Union Pacific Railroad (UPRR) Design Standards
- BNSF Railway Design Standards

1.3.3 DESIGN STANDARD CLASSIFICATIONS

Recommended – Standard to be equaled or exceeded where there are no major physical, cost or schedule constraints. Designers should use 'Recommended' values to the extent practical.

Minimum/Maximum – Represent limits. Designers shall make every effort to avoid the use of minimum/maximum values. These values are acceptable where constraints make the use of 'Recommended' values impracticable.

Shall - Indicates mandatory requirement that must be strictly implemented. Waiver is permissible only under approval of design variance.

Should – Indicates preferred course of action. Design variance is not required if it is not exercised.

May - Indicates permissible course of action within the limits of the standards. Design variance is not required if it is not exercised.

1.3.4 ROLE AND RESPONSIBILITY OF THE DESIGNER

The Criteria contained in this document and in the Standard Plans is intended to provide the designer with flexibility while ensuring that the functionality, goals, and objectives of the FRPR system are met. The Design Criteria shall be used in conjunction with sound engineering judgement, experience, and industry best practices. The Engineering Standards in no way replace the individual designer's adherence to their professional standard of care in system design and development.

Design and construction drawings shall be produced under the responsible charge of a Professional Engineer licensed to practice in the state of Colorado who is appropriately qualified in civil infrastructure design. Final drawings issued for construction or permit review or contracts with outside organizations shall bear the seal and signature of the engineer in responsible charge, pursuant to the rules promulgated by the Colorado Architecture and Engineering Board for sealing. Drawings bound in a set (digitally or physically) may use seals on a title page only as allowed by Board Rules.

1.4 BASIS OF DESIGN

The Colorado Front Range Passenger Rail (FRPR) System is a diesel-electric, steel wheel on steel rail system with standard gauge tracks that shall meet the following physical and functional requirements.

The principle objectives of this design are:

A. Safe, reliable and cost-effective passenger service
B. Use existing rail corridors to ease implementation and design
C. Use existing, commercial off-the-shelf or minimally custom components, including infrastructure and rolling stock elements
D. Build operational infrastructure that can later be upgraded to higher speed or traction modes.

1.4.1 INFRASTRUCTURE

- Dual-track mainline, with sidings to serve secondary stations
- Minimum at-grade crossings of roadways, with quiet zones at all needed at grade crossings.
- Independent capacity, operating with minimized interaction between freight or other commuter and light rail systems

1.4.2 DESIGN SPEED

A design speed of 110 MPH or greater shall be used where cost effective, and conditions allow. A design speed of 125 MPH is permitted when greater than 150 feet away from freight main tracks; per standard drawing D-04. The design shall allow for a cruising speed of 90 MPH, with an absolute minimum of 65 MPH when not within yard limits or approaching primary stations.

1.4.3 PROVEN HARDWARE

The system shall be designed using subsystems consisting of proven equipment and design concepts. Subsystems and spare parts are to have a documented operating history of previous and current usage and be available off the shelf, so far as practical. The same requirements shall apply to spare parts. Waiver of these requirements shall be considered only where the alternative subsystem offers substantial technical and cost advantages, is in an advanced stage of development, and has accumulated substantial test data under near-revenue conditions.

Designs and specifications shall be prepared in such a way as to encourage competitive bidding by established manufacturers of transportation equipment. Industry guidelines from recognized and established organizations such as the American Railway Engineering and Maintenance-of-Way Association, partner Class 1 Railroads, RTD and Colorado Department of Transportation shall be used.

1.4.4 CONCEPT OF FUTURE EVOLUTION

This operational system is intended as the first step of an evolving system, and design at this stage should be reflective of a potential future improvement of the system. Designers should make choices with the intention of the system being upgraded and evolving in the future, particularly focusing on potential electrification, speed increases, or secondary station addition.

1.4.5 ROLLING STOCK AND TRACTION

The FRPR system is designed to use conventional, commercial off-the-shelf rolling stock (or as close as is technically possible with rolling stock).

The rolling stock intended in the first stage of implementation is diesel-electric locomotives, functioning in push-pull configuration with non-powered control unit or cab car, and two or more passenger coaches midtrain. For train performance calculations in ridership estimation, refer to the appropriate definitions memorandum or other documents as relevant.

This rolling stock will presumably be upgraded as the corridor is improved and technology matures in US implementation, and as the corridor and system is built out to ultimate configuration, would be an electric fixed trainset.

1.4.6 CLIMATIC CONDITIONS FOR SYSTEM DESIGN

The Denver metropolitan area, within which FRPR operates, is situated at the foot of the eastern slope of the Rocky Mountains in central Colorado. The area has a semiarid climate that is somewhat characteristic of the High Plains, but is modified by the Rocky Mountains to the west. Because of this, Denver lies in a belt where there is a fairly rapid change in climate from the foothills to the plains. This change is largely caused by the increase in elevation as you travel west to the foothills. Denver has an elevation of 5,280 feet.

The average annual temperature is about 50°F at this elevation, though this varies a few degrees as elevation changes. The wide average range in daily temperature of 25° to 30°F in the Denver metropolitan area and a wide average range in annual temperature are typical for the High Plains. Variations in temperature are wide from day to day; extremely hot weather in summer and extremely cold weather in the winter normally do not last long and are followed by much more moderate temperatures.

System equipment including vehicles, signal system and fare collection/validation equipment along with trackwork, stations and other civil features shall be capable of maintaining operation within the following conditions:

Table 1-1: Climatic Conditions

Ambient Temperature	-30°F - +110°F
Relative Humidity	8 – 100%
Maximum Rainfall in 24 Hours	1.88 inches
Maximum Snowfall in 24 Hours	10.1 inches
Maximum Wind Speed	54 MPH

Average Elevation	5,280 feet AMSL

Data for long periods indicate that the average annual precipitation ranges from 13.5 to 14.5 inches, with the highest precipitation occurring at the western edge of the metropolitan area. Particularly in summer and spring, precipitation may vary from year to year and in different areas in the same year. Precipitation in the winter is more in the western part of the Denver metropolitan area than it is in other parts. These differences are small but consistent from October to May. The annual snowfall is about 59 inches. The eastern part of the metropolitan area, however, usually receives more rainfall in summer than the west, but local rainfall varies widely from year to year. The relative humidity averages 39% during the day and 62% at night, but these averages are slightly higher in winter than in summer. In an average year, the percentage of sunshine is about 69%.

Hailstorms cause some local damage almost every year. The hail usually falls in strips 1-mile-wide and 6 miles long. These storms are more common in the eastern part of the Denver metropolitan area than the western part and they generally occur from about May 15 to September 1 but are most common in June and July.

Requirements for climatic conditions defined in other sections of these Design Criteria take precedence.

1.5 CORRIDOR CONVENTION

Northbound and southbound are defined as relative to compass directions for the originating and destination terminal stations.

Tracks are referenced by number. The track toward the bottom of the drawing is the northbound track and is numbered Track 1. The track toward the top of the drawing is southbound, and numbered Track 2, with additional track numbers proceeding in this manner.

Stationing starts from the southernmost and westernmost point of a given alignment, increasing toward the north and east (similar to Cartesian coordinates). Stationing shall reset to 0+00 at each division boundary, and station equations at division boundaries shall be clearly annotated.

1.6 REFERENCE CRITERIA AND EXAMPLES USED

This document references the following design criteria and engineering standards:

Peninsula Corridor Joint Powers Board – Caltrain: *Design Criteria*, Second Ed. September 30, 2011.

Utah Transit Authority: *Commuter Rail Design Criteria.* Revision 3, March 2015

California High-Speed Rail Authority, Request for Proposals for Design-Build Services for Construction Package 4: *Book III, Part A.1: Design Criteria Manual*, Revision 3, February 2016

Engineering Division, Regional Transportation District: *RTD Commuter Rail Design Criteria*. Revision 01, April 2009.

AREMA Manual

2. DESIGN GUIDELINES

2.1 OPERATIONAL PLANNING

Reserved.

2.2 DESIGN LIFE

The FRPR system's structures, such as bridges, tunnels or culverts shall be designed for a minimum functional life of 75 years. Other fixed facilities (track structure, buildings) shall be designed for continuous operation over a minimum of 50 years before complete refurbishment and renovations are needed due to wear. Signaling systems shall have a design life of 25 years, with signal computer equipment having a design life of 10 years. Train control communication systems shall have a design life of 20 years.

Where possible, functional life and capacity of the system shall be designed to match a design life of a project element, or be sufficiently scalable to accommodate future expansion.

2.3 CLEARANCES

FRPR System shall use a nominal horizontal clearance of 9 feet (per Standard Drawing D-03). Minimum structure vertical clearance shall be 23'-6", with greater clearance required for overhead utility crossings.

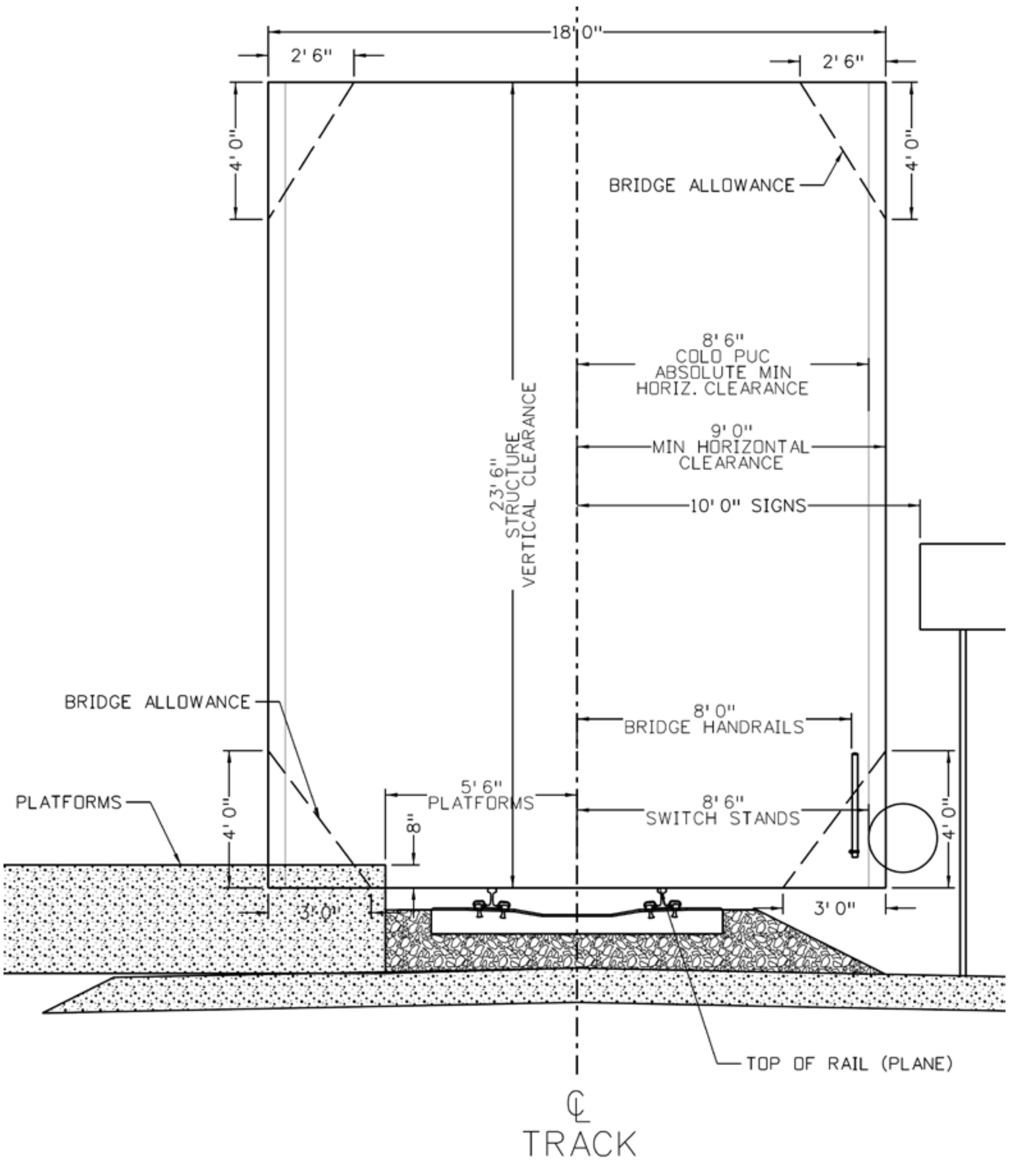

Figure 1: Clearance Diagram. Ref. Std Dwg D-03

2.4 SYSTEM SAFETY AND SECURITY

Reserved.

3. TRACK

3.1 GENERAL

The primary considerations of track design are safety, economy, ease of maintenance, ride comfort, and constructability. Factors that affect the track system such as safety, ride comfort, design speed, noise and vibration, and other factors, such as constructability, maintainability, reliability and track component standardization which have major impacts to capital and maintenance costs, must be recognized and implemented in the early phase of planning and design. It shall be the objective and responsibility of the designer to design a functional track system that meets FRPR's current and future needs with a high degree of reliability, minimal maintenance requirements, and construction of which with minimal impact to normal revenue operations.

3.1.1 TOLERANCES AND CLASS OF TRACK

Track construction and maintenance tolerance shall be within FRA Class 7 as prescribed by 49 CFR Part 213. Deviation to Class 5 may be permitted at the discretion of FRPR Engineering only as track condition and design speeds allow.

3.2 TRACK STRUCTURE

3.2.1 TRACK GAUGE

The FRPR system shall use Standard Gauge, defined as a distance of 4'-8.5" between heads of rails.

3.2.2 TYPICAL SECTION

Typical track section shall consist of two parallel (or concentrically curving) tracks with spacing defined in Section 3.3.2.1 General Alignment and Configuration of Track. The typical section of each track shall consist of two rails, spaced at standard gauge, atop concrete ties, ballast, subballast and a compacted grade. Typical section over structures and through tunnels may omit ballast and subballast as appropriate, instead using low-vibration ballastless track; reference Section 3.2.11: Ballastless Track.

Typical sections and standards are provided in Standard Drawing D-02.

Total mainline corridor width for purposes of Right-of-Way planning shall be 75 feet, widening to 100 feet in anticipated areas of special trackwork or stations.

3.2.3 EXCAVATION AND SUBGRADE

The Contractor shall load, haul, spread, place and compact suitable materials in embankments and shall finish the embankments to the grade, slope and alignment as shown in the plans. Suitable materials shall consist of mineral soils free from organics, debris, and frozen materials. Embankment slopes shall be compacted and dressed to provide a uniform and dense slope. Embankments shall be built with approved materials from excavation of cuts or from borrow unless otherwise shown on the plans.

If materials unsuitable for embankments (organics, debris, brush and trees, etc.) are encountered within the areas to be excavated, or material existing below the designated subgrade in cuts or within areas on which embankments are to be placed are of such nature that stability of the roadbed will be impaired, such material shall be removed and wasted or stockpiled for other use. Topsoil removed from embankment areas shall be spread uniformly over the embankment slopes.

Unsuitable material removed from embankment foundations or below subgrade elevation in excavation areas shall be replaced to grade with suitable material compacted as specified for embankments in these specifications.

Wherever an embankment is to be placed on or against an existing slope steeper than four horizontal to one vertical (4:1), such slope shall be cut into steps as the construction of the new embankment progresses. Such steps shall each have a horizontal dimension of not less than three feet and a vertical rise of one foot.

At all times, the Contractor shall operate sufficient equipment to compact the embankment at the rate at which it is being placed. Compaction shall be accomplished by sheep's foot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Use construction procedures and drainage design that will provide a stable roadbed.

Each layer in embankments made up primarily of materials other than rock shall not exceed 6" in loose depth and shall be compacted to the dry density as specified hereinafter before additional layers are placed.

The subgrade 14 feet both sides of track centerline shall be compacted to at least 95% of maximum dry density, and not more than +4 percent above optimum moisture content as determined by the current revision of ASTM Specification, D1557, Modified Proctor. If laboratory results indicate that existing material is unsuitable (insufficient bearing capacity, poor drainage characteristics, etc.) the material must be removed and replaced with clean, sound and properly compacted material, per ASTM standards.

The compacted subgrade shall be sloped at 2.0% downward and away from the center point located midway between the two tracks in double track territory. In single track areas, the compacted subgrade shall slope away from the centerline at 2.0%.

3.2.4 SUBBALLAST

Subballast is the transition zone between the subgrade and the ballast. The subballast acts as a barrier filter separating the ballast section from the subgrade material and plays an integral role in the track structure. The quality of the subballast has a direct relationship to the overall performance of the track structure. This layer acts as a drainage medium for the track bed.

Subballast shall conform to the requirements for Class 6 Aggregate Base Course, as dictated by CDOT Standard Specification 703.03.

Subballast shall be placed in two six-inch lifts to achieve a minimum depth of 12 inches. When vibratory or other approved types of special compacting equipment are used, the compacted depth of a single layer may be increased to 8 inches upon request, provided that specified density is achieved and written approval is given.

Compaction of each layer shall continue until a density of at least 95 percent of the maximum density has been achieved as determined in accordance with AASHTO T 180 as modified by CP 23. The moisture content shall be at ± 2 percent of optimum moisture content. The surface of each layer shall be maintained during the compaction operations so that a uniform texture is produced and the aggregates are firmly keyed. Moisture conditioning shall be performed uniformly during compaction.

The surface of the base course will be tested with a 10-foot straightedge, or other approved device. The surface shall be tested prior to the application of any primer or pavement. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall not exceed ¼ inch.

3.2.5 BALLAST

No. 4 (1-1/2 inches to 3/4 inches) ballast conforming to AREMA specifications shall be used on all main tracks except for those in streets and yards, where No. 5 (1 inch to 3/8 inch) ballast shall be used. All ballast is to be thoroughly washed prior to placement. Minimum ballast depth shall be 12.0 inches, at a maximum of 18 inches depth.

3.2.6 GEOTEXTILE FABRICS

Reserved.

3.2.7 TIES

New mainline track shall use concrete crossties, approximately 8’-6” on length and 8 ¾” x 11” in cross section. Ties shall be spaced 24 inches center-to-center, reduced to 20 inches in curves with a degree of curvature less than 5°30”.

Hardwood timber ties in compliance with freight railroad standards may be used or retained in shared corridors.

3.2.8 RAIL

The standard rail section shall be 141RE. Rail shall be continuously welded on mainline tracks, with jointed rail only permitted on nonrevenue low speed trackage.

Heat-treated or alloy rails shall be used in all special trackwork and on all curves with Dc=5°30' or greater and extending into the spiral until the point of degree of curve on spiral exceeds Dc=5°30'. Heat-treated or alloy rails are not required to be installed on seldom used emergency or storage tracks, even though they may satisfy the above criteria. Heat-treated or alloy rails may be used, with FRPR approval, in other locations where excessive rail wear is anticipated.

3.2.9 EMERGENCY GUARD RAIL

Emergency guard rails shall be used as a safety measure to capture the inside of the wheel in the event of a derailment and keep the trainset on or near the track. Gard rail shall be installed adjacent to the inside running rail on all tracks on bridges, track on a fill with a vertical drop greater than three feet, and otherwise as directed by FRPR Engineering at critical points. Guard rails shall extend for the length of the structure and for 50 feet on the inbound direction and 10 feet on the outbound. Guard rail shall not be installed through special trackwork.

Guard rails shall be designed so as to retain the wheels of a derailed vehicle moving at the design speed of the track. The striking face of the rail shall be uniformly located approximately 1 foot from the gauge line of the running rail. Guard rail shall be fastened to every second tie in ballasted track.

3.2.10 RAIL SEATS AND FASTENING

Concrete and wooden cross ties will use spring clips isolated from the tie using plastic insulators and placed on an insulating pad.

Rail anchors may be required or retained on existing timber tie freight alignments near tight curves and or at grade road crossings. Rail anchors placement shall follow the design criteria of the dominant freight railroad.

Rail fasteners for use in direct fixation special trackwork shall be of a design compatible with the standard fastener used in conventional direct fixation track.

Rail clips or other devices used in direct fixation fasteners shall produce the required longitudinal rail restraint after repeated load testing in accordance with AREMA Chapter 10, except load application angle in that test shall be 27 degrees.

3.2.11 BALLASTLESS TRACK

Ballastless track designs may be required in tunnels, bridges, or other structural applications. Designs shall be reviewed by FRPR Engineering prior to acceptance in overall design.

Ballastless track (including direct fixation) rail fasteners shall provide the required lateral and longitudinal restraint for continuous welded rail and the electrical insulation required for the negative return current and the proper operation of 60 Hz track signal circuits. Ballastless track fasteners or concrete ties shall provide a 40:1 cant of the rail.

Ballastless track fasteners shall incorporate, or be placed on, a suitable elastomeric pad for reducing transmission of high frequency (i.e., greater than 30 Hz) loads to the support structure.

Engineered transition zones shall be placed at the transition between ballastless and ballasted track sections to mitigate undesirable effect from the change in track modulus.

3.2.12 RAIL WELDING AND JOINTS

Rail shall be welded into Continuous Welded Rail (CWR) strings of site-specific length by the electric flash-butt or aluminothermic welding processes in accordance with AREMA specifications. The ends of welded rail strings shall be field welded together by thermite welding or flash-butt welding according to AREMA specifications.

Insulated and standard rail joints shall be placed only at locations where required to accommodate track signal circuits and connections to special trackwork. The insulated joints for signal operations shall be prefabricated and welded onto ends of CWR. Insulated plugs shall be trimmed to 14 feet. Kits may be used with approval of FRPR Engineering.

3.2.13 RAIL AND SWITCH HEATERS

Switch heaters shall be installed at all power operated turnouts on both mainline and yard tracks. In areas with commercial electrical service, electric switch heaters should be used. For areas without electrical service, designers may consider propane switch heaters.

3.2.14 YARD TRACK

Yard track shall conform to the same standards as mainline track with the following exceptions:

3.2.14.1 SUBBALLAST

Subballast placement may be omitted when no geotechnical need is present.

3.2.14.2 BALLAST

Number 5 ballast conforming to AREMA specifications shall be used on yard tracks.

A minimum depth of 12 inches of ballast shall be used between the bottom of tie and top of subgrade. The top of ballast elevation shall be at least 1 inch below the base of rail and the ballast shoulder shall extend level 1 foot 6 inches to the field side, beyond the ends of the ties to form a suitable walking surface. Crushed slag ballast will not be permitted.

3.2.14.3 TIES

Yard tracks shall use timber cross ties, spaced at 24 inches center-to-center, except at braced and guarded track, where spacing shall be 22 inches center-to-center. Ties shall be 9 feet in length, 7 inches by 9 inches in cross section, and in conformance with AREMA specifications. Switch ties shall be of the lengths and dimensions required for the selected turnout.

3.2.14.4 RAIL

Yard tracks shall be constructed with 136RE new rail and shall be continuously welded.

3.2.14.5 GUARD RAIL

Emergency guardrail shall be installed where tracks are adjacent to major structures or where a derailment may cause extensive damage to cars or structures.

3.2.14.6 CROSSINGS

Grade crossings for yard operations may be constructed of asphalt with flangeway liners. Crosswalks may be constructed of asphalt with flangeway liners, and may be located in curves.

3.2.14.7 ILLUMINATION

Yards shall be lighted sufficiently to provide adequate working light for 24-hour operations.

3.3 GEOMETRY

The primary goals of geometric criteria for FRP are to provide a safe, cost effective, efficient, and comfortable ride, while maintaining adequate factors of safety with respect to overall operations, maintenance, and vehicle stability.

The geometric design criteria for trackwork have been developed using the best engineering practice and the experience of comparable operating Commuter and Class 1 railroads. The designers should to strive to balance among the following competing principles:

A. Consideration of overall system safety
B. Optimization of passenger comfort
C. Maximization of speed
D. Effectiveness of implementation costs
E. Ease and efficiency of maintenance

3.3.1 GENERAL GEOMETRIC DESIGN REQUIREMENTS

3.3.1.1 SELECTION OF SPECIFIC DESIGN SPEED

Alignments should be designed to minimize the use of curves and to maximize the potential operating speed of the system.

Table 3-1: System Design Speeds

Recommended Design Speed	110 MPH	Or greater if conditions permit. This will maximize future capability of expansion and upgrading
Cruising Speed	90 MPH	Target minimum speed to ensure effective system operation
Minimum Mainline Design Speed	65 MPH	Absolute minimum for mainline tracks – will adversely impact system operation
Yard or Station Limits	30 MPH	Or otherwise as determined appropriate for acceleration out of stations or similar.

3.3.2 HORIZONTAL ALIGNMENT

The horizontal alignment of track consists of a series of tangents joined to circular curves and spiral transition curves as measured along the center line of track. Track superelevation in curves is used to maximize train operating speeds wherever practicable. In yards and other non-revenue tracks, spiral transition curves are rarely required.

Curvature and superelevation of track alignment are related to design speed and to the acceleration and deceleration characteristics of the rail cars and locomotives for that location.

The design criteria for tangent, curve, design speed, superelevation, and spiral transition curve are described in the next few sections.

3.3.2.1 GENERAL ALIGNMENT AND CONFIGURATION OF TRACK

Horizontal alignments for FRPR mainline tracks shall be stationed along track centerlines from south to north and west to east.

When possible, double track alignment shall be designed with a constant distance between track centerlines. Segments along straight tracks should be parallel, and curvature should be concentric maintaining a parallel nature at the entry and exit to curves.

Mainline tracks are recommended at 25.0 feet, with a minimum acceptable spacing at 16.5 feet. Absolute minimum spacing (speeds less than 90MPH only) shall not be less than 15.0 feet. Yard or other nonrevenue tracks shall have a minimum spacing of 15.0 feet.

Track centers through curves do not need to be increased if they are greater than 16.5 feet, and if less than 16.5 feet, shall be widened according to:

Equation 3-1: Curve Widening of Track Centers

$$Track\ Centers\ (feet) = 14.7 + \frac{1{,}100}{R\ (feet)}$$

In case of curves under 3,000 feet radius and the inside track is superelevated to a lower extent than the outside track, track centers shall be widened to twice the difference in superelevation (inches).

The clearance (fouling) point shall be located at the point that track centers are less than 14.0 feet as diverging.

3.3.2.2 TANGENTS

Horizontal tangents shall be designed based on the longest rail car length for the rail corridor and ride comfort for the passengers. A formula for tangent length in feet (L=3V) where V is the design speed (MPH) for ride comfort is based on the rail car traveling at least three (3) seconds on tangent track between two curves. Tangent shall extend at least 100 feet beyond both ends of the limits of the station platforms, and of at-grade crossings.

3.3.2.3 HORIZONTAL CURVES

Maximum speeds permitted in curves are governed by 49 CFR §213.57, where

Equation 3-2: Vmax (FRA Speed Limit)

$$V_{\max} = \sqrt{\frac{E_a + E_u}{0.0007D}}$$

Where E_a is the superelevation of the outside rail (inches), E_u is the maximum allowable cant deficiency of the vehicle, and D is the degree of curvature (chord-definition).

Track shall use circular curves with spiral transitions as described in Section 3.3.2.4.

3.3.2.4 SPIRALS

Spirals (transition or easement curves) are defined as transition curves with a constantly decreasing or increasing radius proportional between either a tangent and a curve (simple spiral) or between two curves with different radii (compound/intermediate spiral). More specifically, the spiral is a curve whose degree-of-curve increases directly as the distance along the curve from the point of spiral.

In other words, spirals provide a gradual change of curve and ride comfort from the tangent to full curvature. Spirals are a means of introducing a superelevation at a rate corresponding to the rate of increase in curvature, which permits a gradual increase to full lateral acceleration at a comfortable, and non-destructive rate.

The spiral transition curves shall be provided between circular curves and horizontal tangents. The spiral transition curve shall be the “ten-chord spiral” as defined by the AREMA Manual for Railway engineering or the “clothoid spiral”. Clothoid spirals provide a constant rate of change in curvature between the tangent and the connecting circular curve. Clothoid spirals shall be used on tracks having design speed lower than 110 mph. Clothoid spirals may be used on large radius curves that require small amounts or no superelevation and small unbalanced superelevation.

Spiral transitions may be omitted for curves less than 30 minutes (Radius > 11,459 feet), or when a curve is a part of a turnout (but these curves must have a length greater than 100 feet).

The length of spiral shall be longest as determined from formulas (Recommended Values):

1. $L_s = 1.63\, E_u\, V$ – Unbalance determined
2. $L_s = 1.47\, E_a\, V$ – Superelevation determined
3. $L_s = 90\, E_a$ – Vehicle twist
4. $L_s = \ 2.64\, V$ – Minimum segment

The *minimum* spiral lengths shall be the longest determined from:

A. $L_s = 1.22\, E_u\, V$ – Unbalance determined
B. $L_s = 1.17\, E_a\, V$ – Superelevation determined
C. $L_s = 75\, E_a$ – Vehicle twist
D. $L_s = \ 2.20\, V$ – Minimum segment

Where L_s = Length of spiral, E_a is the superelevation of the outside rail (inches), E_u is the maximum allowable cant deficiency of the vehicle, and V is the design speed (miles/hour)

3.3.2.5 SUPERELEVATION

Superelevation is the height difference in inches between the high (outside) and low (inside) rail. Superelevation is used to counteract, or partially counteract the centrifugal force acting radially outward on a train when it is traveling along the curve. A state of equilibrium is reached when the centrifugal force acting on a train is equal to the counteracting force pulling on a train by gravity along the superelevated plane of the track. The superelevated track results in improved ride quality, and reduced wear on rail and rolling stock.

Actual superelevation shall be accomplished by maintaining the top of the inside (or low) rail at the "top of rail profile" while raising the outside (or high) rail by an amount of the actual superelevation. The inside rail is designated as the "grade rail" (or profile rail) and the outside rail is designated as the "line rail".

Equilibrium superelevation shall be determined by the following equation:

$$e = 0.0007\, D\, V^2$$

Where e = total superelevation (inches), D = degree of curvature (chord definition), V=maximum design speed (miles/hour).

The total superelevation is expressed as:

$$e = E_a + E_u$$

Where E_a is the superelevation of the outside rail (inches), E_u is the maximum allowable cant deficiency of the vehicle.

The actual superelevation shall be rounded to the nearest 1/4 inch. A superelevation of ½ shall be required for all curves. Curves in slower speed track (such as yard or other nonrevenue track), and curves in special trackwork shall not be superelevated. Curves within stations and grade crossings should be avoided to the maximum extent practical.

The FRP system shall be designed with a maximum allowable cant deficiency (maximum unbalance) of **3 inches**.

3.3.3 VERTICAL ALIGNMENT

The vertical alignment shall be defined by the profile grade represented by the top of rail (TOR) elevation of the low rail. This low rail is the grade rail. When TOR profile is given for one track only, the TOR elevations of the other tracks are to be equal to the profile track at points radially and perpendicularly opposite.

Gradients and lengths of vertical curves shall vary accordingly, (slightly), to accommodate the differences in lengths through horizontal curves. All main tracks and sidings shall be designed to the same vertical profile. In multi-track territories where there are more than two tracks, the profile of the outside tracks may be lowered based on the cross slope of the roadbed to minimize the need of increasing ballast depth.

3.3.3.1 GRADES

The maximum continuous main line grade on the FRPR system is 1.25%. Grades of 1.25% to 1.5% shall be permissible for lengths not to exceed 2,500 feet. Grades greater than 1.5% shall be permissible only with engineering review and approval, and grades shall not exceed 2.25% under any circumstance.

Station track shall have a maximum grade of 0.35%, with an absolute maximum of 0.50%. Yard and storage tracks shall have a maximum grade of 0.10%, with an absolute maximum of 0.30%.

3.3.3.2 VERTICAL CURVES

Vertical tangents shall be connected with parabolic vertical curves to transition between differing grades. Length of vertical curves should be rounded up to the nearest 100 feet as practical. The minimum distance between vertical curves shall be 100 feet.

The minimum length of vertical curves shall be determined by:

Equation 3-3: Length of Vertical Curves

$$L_{VC} = \frac{2.15\,V^2 * D}{A}$$

Where V=design speed of the curve, D is the absolute value of the difference in grades (decimal feet/feet), and A is the allowable vertical acceleration (ft/sec^2)

Maximum allowable vertical acceleration (A) shall be 0.60 ft/sec^2 (per AREMA §3.6.g).

3.3.3.3 COMPENSATED GRADIENT

Maximum gradient where there are horizontal curves shall be compensated to equate total resistance of a train on a horizontal curve on a gradient to that of a train on a tangent gradient. Gradient compensation is determined using a compensation factor of 0.04%/Dc, as recommended by AREMA Section 3.7.1.

Compensated maximum gradient shall be determined by:

Equation 3-4: Grade Compensation

$$G_c = G - 0.04\,D$$

Where G_c = compensated gradient (percent), D = degree of curve (decimal, chord definition), and G = gradient before compensation.

3.4 SPECIAL TRACKWORK

Special trackwork refers to track components that are used for the convergence, divergence or crossing of track. Special trackwork includes turnouts (switches), crossovers, derails and crossings.

All special trackwork design should be based on FRPR Standard Drawings, and if no standard exists on AREMA Drawings. Other design standards from Class 1 Railroads in the operating area may be used with approval of FRPR Engineering. Use of substandard or alternative turnout designs and configuration shall be permitted only when no practicable alternative exists and with approval of FRPR Engineering.

3.4.1 TURNOUTS

Turnouts are used for tracks to diverge or converge from one track to another. Turnouts are divided by types and sizes (numerical). Each unit consists of points, frog, straight and curved stock rails, and the mechanical means to move the points (and occasionally frog) into alignment for the direction of movement.

The frog is the component of the turnout or crossing where wheels move from one track to another. Turnout size is denoted by a frog number, which is the arctangent of the frog angle.

3.4.2 CROSSOVERS

Reserved.

3.4.3 DERAILS

Derails are mechanical and/or electrical safety devices intentionally used to derail or divert uncontrolled movement of train, rail vehicles, or on-track equipment away from adjacent or connecting tracks without fouling the tracks. See FRPR Standard Drawings for layouts and details. The designer shall closely coordinate with the signal designer for design and layout requirements.

Derails shall be installed on the connections of lead tracks or yards to the main line if cars are moved or stored on said track. Derails may be needed in other areas at the direction of FRPR Engineering to mitigate risk of errant cars or locomotives causing to injury passengers or personnel or that may damage equipment or infrastructure.

Derails shall be located such that they derail equipment away from the main track. Derails shall be located past the clearance point. Derails shall be connected to the signal system to indicate alignment for movement or derail protection.

Derails with blue flag signals are required to protect workers at service facility areas as per 49 CFR 218.

3.4.4 RAILROAD CROSSINGS

At-grade intersections of tracks where they cross over one another (railroad crossings or diamond crossings) shall require approval from the FRPR Engineering team and shall only be permitted when there is no other economical or feasible option. If installed, crossings may only be located on tangent track at the skew angles recommended by AREMA.

3.5 OTHER TRACK CONSIDERATIONS

3.5.1 MAINTENANCE ACCESS

Access points for maintenance personnel and equipment shall be provided everywhere possible. Areas shall be provided at or near wayside equipment for the parking of maintenance vehicles to prevent infringing on roadway travel lanes or pedestrian areas.

High-rail access points shall be provided at least every 4 miles when possible and if deemed necessary. They shall be located on tangent track and be constructed of grade crossing materials durable enough to withstand maintenance vehicles. Highrail access points shall be adequately secured to prevent unauthorized entry.

Maintenance access points shall be equipped with fire department access keys (Knox™ or similar as approved by the fire AHJ) or other provisions shall be made for emergency access along the right of way.

4. GRADE CROSSINGS

The term “grade crossings” or “crossings” in this document refers to all crossings at-grade. Grade crossings are commonly referred in the technical literature and government publications as at-grade highway-rail crossings or simply highway-rail crossings or, the more recent pathway grade crossings. This section also covers pedestrian grade crossings.

Grade crossings are intersections where vehicles and/or pedestrians cross train tracks at the same elevation, whereas at these locations the train always has the right of way. By definition an intersection is an area of potential conflict, i.e., two (2) users cannot occupy the same space at the same time. The term, motorized users or motorists, denote all types of vehicular drivers (automobiles, buses, trucks, motorcycles, etc.). The term non-motorized users or non-motorists refers to all pedestrians, which includes mobility impaired persons, wheelchair occupants, and bicyclists.

The grade crossing design consists of three (3) essential elements: safety, accessibility, and functionality. In order to achieve these, the grade crossing requires a clearly defined and readily traversable pathway for both the motorist and pedestrian. In addition to the defined pathway, the grade crossing limits need to be clearly delineated. That is, those areas where a pedestrian or motorist can safely wait for a train to pass, or where a pedestrian or motorist has passed beyond the area of potential conflict must be readily apparent. One of the key consideration in the design is the crossing that would encourage lawful behavior.

4.1 POLICY

Grade crossings shall be permitted in the design and construction, but the number of crossings shall be limited to the greatest degree possible. FRPR intends to implement quiet zones in urban or residential areas.

Intersections of the FRPR system and any State Highway (Interstate, US Highway or State Highway) shall be grade separated. If the State Highway intersection is not classified as a freeway or Interstate, at-grade intersections may be permitted with the approval of FRPR Management and the appropriate CDOT Regional Management Team.

Intersections of roadways classified as arterials by the local municipality or county shall be considered for grade separation. Grade separation may be warranted based on interest of the municipality, traffic volume on the intersected road, and/or other design needs and engineering judgments.

Grade crossings near residential or urbanized areas (as determined by FRPR Engineering) shall be designed with the intention of quiet zone implementation, as dictated by Section 4.1.4.

4.2 PRINCIPLES

Because it is site specific, each grade crossing is unique and complex. Each of the three (3) different types of user groups (trains, vehicles, pedestrians) has distinct characteristics in crossing behavior and limitations. And among users of the same group these differences vary widely. The system design needs to address the needs and capabilities of each of these user groups.

The underlying principle of grade crossing safety is to provide a defined path for safe passage across the tracks in an expeditious and efficient manner. Safety is enhanced by credible warning devices which are appropriate to the different target users.

All of the grade crossings of public roadways shall be equipped with an active crossing warning system to provide notice that a train is approaching sufficient warning time for the motorist and pedestrian to stop short of the crossing, or if they have already entered the crossing, to safely continue past the area of potential conflict.

All grade crossings shall be equipped with an Emergency Notification Sign (I-13), which clearly delineates the emergency contact phone number and crossing number.

The crossing shall be designed to provide the required integration between the pedestrian grade crossing and the sidewalk. Ideally, there shall be adequate access in width to accommodate the wheel chairs in accordance with ADA requirements. In addition, the crossing shall transition smoothly integrating with the surrounding footpath and road network. The design shall be clear of obstructions and provide adequate maneuvering space in a consistent manner for wheelchairs, strollers, and bicycles. If sidewalk is absent, a smooth transition shall be provided.

Any modifications to the existing grade crossings, whether rehabilitation or improvement require an integrated effort among the civil, and signal disciplines, as well as roadway traffic signaling.

4.3 GENERAL REQUIREMENTS

4.3.1.1 GEOMETRY

The geometric characteristics of a grade crossing directly impact the sight distance for the users. The sight distance is characterized by the horizontal and vertical alignment, transition from track to the roadway, and crossing surface. Vertical curves should be of sufficient length to ensure an adequate view of the crossing.

The grade through the crossing shall follow the track profile and grade, which shall generally be flat for crossings not on curves requiring rail superelevations. This will enhance the view of the crossing, and from the standpoint of sight distance, ride quality, braking, and acceleration distances.

Ideally, the roadway should intersect the tracks at a right angle and with no nearby intersections or driveways. When the right angle is not possible, the skew of the roadway should be reduced as much as possible to facilitate ease of crossing. For the motorists, this layout enhances the view of the crossing and tracks, and reduces conflicting vehicular movements from crossroads and driveways. To the extent practical, crossings should not be located on either roadway or track curves.

Skewed crossings are potential hazards for pedestrians. They lengthen the crossing, and because of the rail flangeway, increase the hazards to pedestrians, especially people on wheelchairs and strollers, as well as to the visually impaired persons.

4.3.1.2 VISIBILITY

Approaching crossings (within 150 feet), fences other than the center fence at stations higher than four (4) feet, vegetation higher than three (3) feet, signs not part of the passive traffic control devices, cases, cabinets, or any equipment or structures or other physical sight obstructions which interfere the view of the warning devices are discouraged.

4.3.1.3 ILLUMINATION

A well-lighted crossing will assist the motorists, pedestrian, and bicyclists to assess the conditions of the crossings, the crossing warning devices, and roadway conditions.

Designers shall consider the installation of roadway or pedestrian path lighting in urban areas or where expected volumes of traffic are high. Illumination should be considered when roadway geometry makes illumination of the crossing via the headlights of the vehicle inadequate.

4.3.1.4 MATERIALS

Mainline grade crossings shall be prefabricated and made of durable, long-lasting materials. Grade crossing panels shall be constructed with due regard to removability for track maintenance, electrical isolation, to non-interference with electrical track circuits or rail fastenings, tire adhesion, and slip resistance for vehicles and pedestrians.

Cross tie type, size and spacing at grade crossings shall be in accordance with the grade crossing manufacturer's recommendations. If the grade crossing requires cross ties that differ it type from the mainline track, then transition zones shall be designed to accommodate for the change in track modulus.

4.3.1.5 CROSSING SURFACE

Reserved.

4.4 QUIET ZONE DESIGN REQUIREMENTS

Crossings at locations intended for quiet zone designation shall include the installation of engineered Supplementary Safety Measures (SSMs) as needed to reduce the Quiet Zone Risk Index (QZRI) below the Nationwide Significant Risk Threshold (NSRT).

Designers should consult FRA Part 222 for specific guidance and the regulatory procedures that shall prevail over these design criteria if more stringent or in conflict.

4.4.1.1 SUPPLEMENTARY SAFETY MEASURES (SSM)

The following SSMs are approved for implementation for quiet zone compliant design on the FRPR System. Use of other SSMs or ASMs shall be approved by FRPR Engineering in advance of design progressing.

4.4.1.1.1 FOUR-QUADRANT GATES

Four-quadrant gates fully block all traffic from entering the crossing when gates are lowered, with one gate provided per direction of travel.

Four-quadrant gates may be supplemented with presence detection, such that exit gates remain raised if traffic is occupying crossing area.

Four-quadrant gate systems shall conform to the standards for four-quadrant gates contained in the MUTCD and shall, in addition, comply with the following:

A. When a train is approaching, all highway approach and exit lanes on both sides of the highway-rail crossing must be spanned by gates, thus denying to the highway user the option of circumventing the conventional approach lane gates by switching into the opposing (oncoming) traffic lane in order to enter the crossing and cross the tracks.
B. Crossing warning systems must be activated by use of constant warning time devices unless existing conditions at the crossing would prevent the proper operation of the constant warning time devices.
C. Crossing warning systems must be equipped with power-out indicators.
D. The gap between the ends of the entrance and exit gates (on the same side of the railroad tracks) when both are in the fully lowered, or down, position must be less than two feet if no median is present. If the highway approach is equipped with a median or a channelization device between the approach and exit lanes, the lowered gates must reach to within one foot of the median or channelization device, measured horizontally across the road from the end of the lowered gate to the median or channelization device or to a point over the edge of the median or channelization device. The gate and the median top or channelization device do not have to be at the same elevation.
E. ‘‘Break-away’’ channelization devices must be frequently monitored to replace broken elements.

Design of four-quadrant gates should consider:

A. Gate timing should be established by a qualified traffic engineer based on site specific determinations. Such determination should consider the need for and timing of a delay in the descent of the exit gates (following descent of the conventional entrance gates). Factors to be considered may include available storage space between the gates that is outside the fouling limits of the track(s) and the possibility that traffic flows may be interrupted as a result of nearby intersections.

B. A determination should be made as to whether it is necessary to provide vehicle presence detectors (VPDs) to open or keep open the exit gates until all vehicles are clear of the crossing. VPD should be installed on one or both sides of the crossing and/or in the surface between the rails closest to the field. Among the factors that should be considered are the presence of intersecting roadways near the crossing, the priority that the traffic crossing the railroad is given at such intersections, the types of traffic control devices at those intersections, and the presence and timing of traffic signal preemption.
C. Highway approaches on one or both sides of the highway-rail crossing may be provided with medians or channelization devices between the opposing lanes. Medians should be defined by a non-traversable curb or traversable curb, or by reflectorized channelization devices, or by both.
D. Remote monitoring (in addition to power-out indicators, which are required) of the status of these crossing systems is preferable. This is especially important in those areas in which qualified railroad signal department personnel are not readily available.

4.4.1.1.2 CHANNELIZATION DEVICES AND MEDIANS

Channelization and median installation may be used as a design option to deny the highway user the option of circumventing the approach lane gates by switching to the opposing (oncoming) traffic lane to drive around the lowered gates to cross the tracks.

Design of this SSM shall be such that:

A. Opposing traffic lanes on both highway approaches to the crossing must be separated by either: (1) medians bounded by non-traversable curbs or (2) channelization devices.
B. Medians or channelization devices must extend at least 100 feet from the gate arm, or if there is an intersection within 100 feet of the gate, the median or channelization device must extend at least 60 feet from the gate arm.
C. Intersections of two or more streets, or a street and an alley, that are within 60 feet of the gate arm must be closed or relocated. Driveways for private, residential properties (up to four units) within 60 feet of the gate arm are not considered to be intersections under this part and need not be closed. However, consideration should be given to taking steps to ensure that motorists exiting the driveways are not able to move against the flow of traffic to circumvent the purpose of the median and drive around lowered gates. This may be accomplished by the posting of ‘‘no left turn’’ signs or other means of notification. For the purpose of this part, driveways accessing commercial properties are considered to be intersections and are not allowed. It should be noted that if a public authority cannot comply with the 60 feet or 100 feet requirement, it may apply to FRA for a quiet zone under § 222.39(b), ‘‘Public authority application to FRA.’’ Such arrangement may qualify for a risk reduction credit in calculation of the Quiet Zone Risk Index. Similarly, if a public authority finds that it is feasible to only provide channelization on one approach to the crossing, it may also apply to FRA for approval under § 222.39(b). Such an arrangement may also qualify for a risk reduction credit in calculation of the Quiet Zone Risk Index.

D. Crossing warning systems must be activated by use of constant warning time devices unless existing conditions at the crossing would prevent the proper operation of the constant warning time devices.
E. Crossing warning systems must be equipped with power-out indicators.
F. The gap between the lowered gate and the curb or channelization device must be one foot or less, measured horizontally across the road from the end of the lowered gate to the curb or channelization device or to a point over the curb edge or channelization device. The gate and the curb top or channelization device do not have to be at the same elevation.
G. ''Break-away'' channelization devices must be frequently monitored to replace broken elements.

4.4.1.2 WAYSIDE HORNS

Wayside horns may be installed in areas where sound from locomotive horns is a nuisance, but the configuration of the area does not warrant the installation of a full quiet zone.

A wayside horn conforming to the requirements of Appendix E of FRA Part 222 may be used in lieu of a locomotive horn at any highway-rail grade crossing equipped with an active warning system consisting of, at a minimum, flashing lights and gates.

4.5 SIGNALING

Reserved.

4.6 TRAFFIC CONTROL DEVICES

4.6.1 ACTIVE TRAFFIC CONTROL DEVICES

Reserved.

4.6.2 PASSIVE TRAFFIC CONTROL DEVICES

Reserved.

4.6.3 PEDESTRIAN TREATMENTS

Reserved.

4.6.4 TRAFFIC SIGNAL PREEMPTION

Reserved.

4.7 VEHICULAR CROSSING DESIGN

Reserved.

4.8 PEDESTRIAN CROSSING DESIGN

Reserved.

5. CIVIL DESIGN

5.1 GENERAL

Reserved.

5.2 SURVEY AND GEODETIC CONTROL

5.2.1 GENERAL

Locating, preserving, referencing, installing and restoring land monuments such as Primary Control monuments from which the Right of way or any land boundary will be calculated, described or monumented, Public Land Survey System (PLSS) monuments, General Land Office (GLO) monuments, Bureau of Land Management (BLM) monuments, Mineral Survey (MS) monuments, Right of way (ROW) monuments, property boundary monuments, easement monuments, and other monuments that are required by law or regulation to be established by a PLS, and the determination of any land boundary, shall be done in accordance with Section 629 of the CDOT Standard Specifications, under the supervision of a Professional Land Surveyor (PLS) who is experienced and competent in Right of way and boundary surveying and licensed in the State of Colorado.

The PLS or PE shall be available to review work, resolve problems, and make decisions in a timely manner.

Unless specified otherwise in the Contract, all survey procedures shall be in conformance with the CDOT Survey Manual.

5.2.2 CONTROL

5.2.2.1 HORIZONTAL CONTROL

The Horizontal Control for all system-level alignment design shall be based on the Colorado State Plane system, Central Zone, and the North American Datum of 1983 (NAD83).

Specific coordinate transformations may be done for final design of segments, and the surveyor shall develop a Project Control Diagram detailing the control monuments, latitude and longitudes and State Plane Coordinates for monuments, and the transformation needed to ground coordinates for construction.

Design and survey shall use the U.S. Survey Foot.

The minimum accuracy of survey work based on the control network shall be one part in 20,000 for linear measurements and 5 seconds per transit station for angular measurements. Legal descriptions of transit R.O.W. shall be tied into the established property lines of adjacent properties and on established section monumentation

5.2.2.2 VERTICAL CONTROL

The Vertical Control for all projects shall be based on the North American Vertical Datum of 1988 (NAVD 88). Where the proposed work is to be in a certain relationship to an existing structure or facility, elevations of the existing structure or facility must be established by field survey and tied to existing benchmarks. Where the proposed project is to be coordinated with other work, the relationship between the project datum and other working datums shall be established by field survey and tied to existing benchmarks.

5.3 CLEARANCES

Reserved.

5.4 STREET DESIGN

Reserved.

5.5 DRAINAGE

Reserved.

5.6 UTILITIES

Reserved.

6. STRUCTURES

6.1 STANDARDS, CODES AND GUIDELINES

Reserved.

6.2 DESIGN METHODOLOGY

Reserved.

6.3 GENERAL DESIGN GUIDELINES

Reserved

6.4 LOADING

Reserved

6.5 SEISMIC DESIGN CONSIDERATIONS

Reserved

6.6 STRUCTURE TYPE SELECTION

Reserved

6.7 CONCRETE STRUCTURES

Reserved

6.8 STEEL STRUCTURES

Reserved

6.9 BRIDGE BEARINGS

Reserved

6.10 WATERPROOFING

Reserved

6.11 CULVERTS

Reserved

6.12 PERMANENT RETAINING WALLS

Reserved

6.13 LOAD RATING

6.13.1 DESIGN LOADING

6.13.1.1 COOPER E80

Reserved

6.13.1.2 AMTRAK CONSIST

Reserved

6.13.1.3 COMMUTER CONSIST

Reserved

7. STATIONS

7.1 GENERAL

This section establishes specific guidelines and standards for the design of stations. The stations will be at-grade (except in special cases), standardized and cost effective in design. Elements discussed in this section include the design of platforms or platform access. Guidelines are provided for the design of bus access, kiss-and-ride and park-and-ride facilities, and for the selection of materials.

These criteria intend to enhance the safety and quality of the system, which has a fundamental impact on the ability to attract and sustain patronage.

A rail station consists of site access, parking (modal access), transition plaza, platform, tracks, and all appurtenances necessary to provide for the public safety, protection from the elements, and public information. The station also serves as a gateway in and out of a community as the origin/destination source of passenger traffic.

The general design of the stations shall be standardized. Equipment, shelters, platform features, structural elements, and signage used shall be the same system-wide and compatible with FRPR's existing identity. Deviations from standard design elements may be required for specific sites, but must be approved by FRPR before design proceeds.

FRPR and community planners should explore potential opportunities to develop transit-oriented development (TOD) adjacent to FRPR station locations. TOD, however, needs to occur with a balance toward providing a convenient and pleasant experience for FRPR passengers and providing opportunities for mixed use development.

7.1.1 GOALS

The basic goals for these criteria are to provide the design professionals with the information necessary to maximize the design effort in providing a safe functional station. The station area must provide a safe and efficient transition from multi-modal arrival areas through a space that provides ticketing, schedule and community/regional information; to a station platform (concourse) that provides a safe area from which to board the Commuter Rail trains. All station areas must take into account the safety and comfort of the patron through appropriate lighting and protection from the elements. These criteria cover that portion of station design from the bus boarding/alighting location to the train platform. For criteria on park and Ride design, reference the standards of the local transit agency.

7.2 STANDARDS, CODES AND GUIDANCE

Reserved.

7.3 STATION CLASSIFICATION

Station locations are broken down into two classifications, each with requirements for the class and specific design criteria. For the purpose of station classification, the population of a municipality and general catchment area is defined as either the boundaries of the jurisdiction or the population surrounding the station location within a five (5) mile radius.

7.3.1 PRIMARY STATIONS

Primary stations are the principal stations that serve major communities with large capture areas, large anticipated ridership, and that would receive service from all FRPR trains.

7.3.1.1 REQUIREMENTS OF PRIMARY STATIONS

Primary Stations must:

1. Be located within a municipality (or within close proximity to a municipality) with a population greater than 55,000,
2. Be located within the general corridor of the FRPR system,
3. Not be within eight (8) miles of another primary station, and
4. Provide connectivity to a regional or local transit system.

7.3.2 SECONDARY STATIONS

Secondary stations are those that do not serve major metropolitan areas, but that provide significant additional ridership and connectivity, and may serve special events or non-municipal station locations. Secondary stations would be served by local service trains, but would not be served by express service.

7.3.2.1 REQUIREMENTS OF SECONDARY STATIONS

Secondary stations must:

1. Serve a population exceeding 10,000 persons or anticipated ridership from special events exceeding 10,000 persons,
2. Be adequately located within the FRPR system (not requiring a realignment of the system corridor to serve the station),
3. Be sufficiently located to provide connectivity to transit-oriented development or transit system connectivity, and
4. Not be within three (3) miles of another primary or secondary station.

7.4 STATION CONFIGURATION

Consideration shall be given to possible track additions and possible extensions in the future, for longer train consists. The station designers shall seek inputs from FRPR in determining requirements for possible future station expansion and provision for future Electrification of the system.

The station layout shall include provisions for roadway maintenance trucks to access the tracks on both sides of the station. If this access is to be provided from the public parking or driveway areas, a locked gate shall be installed to keep unauthorized vehicles from entering the right-of-way.

7.4.1 TRACK

Areas with tangent track are preferred, and curved track should be avoided if at all possible. If placement on a curved track is unavoidable, the curve shall be no more than 1 degree and 30 minutes, and be located at either end of the platform. Platforms located on a curve shall be approved in advance from FRPR Engineering.

Station track shall have a maximum grade of 0.35%, with an absolute maximum of 0.50%. (Ref. 3.3.3.1 Grades)

Track centers shall be a minimum of 18 feet through station areas, to ensure that central fencing is a minimum of 8'-6" from track centerline.

Primary stations (as defined in 6.3 Station Classification) may be located on the main track with no provisions for passing. Secondary stations shall be located on a siding, such that express trains serving all stations would be able to pass the local service train at a passing siding. Passing sidings for stations shall be a minimum of 1000 feet in length, with 1500 feet or longer preferred.

7.4.2 BOARDING PLATFORMS

The two preferred alternatives for FRPR station platforms are as follows:

A. Outboard Platforms: Outboard platforms are side platforms located directly opposite one another, each servicing one mainline track.
B. Center Island Platform: Center island platform is a single platform that services tracks located on each side of the platform. The center island platform arrangement is considered to offer the most efficient use of platform space and furnishings.

The staggered platforms are outboard platforms where the platforms do not align, or are staggered either around or not around an adjacent street. These platforms are neither efficient nor convenient for passengers, and may be used on a temporary basis such as temporary station during construction. See FIGURES XXX-YYY for typical platform arrangements. See FRPR Standard Drawings (P series) for further details.

Platforms including potential extensions will be located at least 100 feet from the nearest road crossing in order to prevent the locomotive of a stopped train from obstructing the crossing. If the location of the station causes train operations to be affected by the "Train Delayed within a Block" rule (GCOR 9.9), the station project shall include modifications to the signal system to avoid such a delay. This is usually accomplished by adding or re-spacing automatic block signals.

7.4.2.1 PLATFORM DIMENSIONS

Platforms shall be at an elevation eight (8) inches above the top of rail. The platform edge shall be 5 feet 6 inches (5'-6") from the centerline of nearest track. Platforms are to be constructed of concrete with flush vertical wall on the track side. Designer shall seek inputs from FRPR on the final profile and alignment for the tracks through the station area to establish the platform elevation.

7.4.2.1.1 PLATFORM LENGTH

The standard platform length shall be 700 feet to allow for six car consists. Platform design shall consider or not preclude a possible expansion of platform length to 1000 feet (for eight car consists).

Terminal stations should be sized larger or have other provisions to accommodate four trains (two stored, two on platforms) at any point in time.

7.4.2.1.2 PLATFORM WIDTH

Outboard platforms shall be a minimum of 16 feet wide, with 20 feet preferred. Center platforms shall be a minimum of 28 feet wide, with 32 feet preferred. This added width is to accommodate access stairs, ramps, elevators, shelters and for passenger access and circulation. A minimum walking space of seven (7) feet shall be required from the safety stripe to any obstruction for the entire length of the platform.

7.4.2.1.3 SLOPE

All side platforms should slope away from the track a minimum of 1 percent and no more than 2.0 percent in accordance with ADA guidelines. At center platforms, the slope shall be to a centerline swale with area drains for discharge to the municipal storm drain system. Drain the entire station site and contiguous railroad ROW.

7.4.3 PEDESTRIAN CROSSINGS

Reserved.

7.5 GENERAL STATION REQUIREMENTS

7.5.1 ADA REQUIREMENTS

Reserved.

7.5.2 FENCING

Reserved.

7.5.3 SIGNAGE
Reserved.

7.5.4 UTILITIES
Reserved.

7.5.5 DRAINAGE
Reserved.

7.6 AMENITIES
Reserved.

7.7 ACCESS AND CIRCULATION
Reserved.

8. COMMUNICATIONS AND CONTROL

Reserved.

9. SIGNAL SYSTEM

Reserved.

10. SYSTEM SAFETY AND SECURITY

Reserved.