# National Railroad Passenger Corporation

# LIMITS AND SPECIFICATIONS FOR TRACK SAFETY, MAINTENANCE AND CONSTRUCTION

**MW 1000**

**Office of the Deputy Chief Engineer-Track 30th Street Station**
**Philadelphia, PA 19104**

**Effective December 11, 1976**
**Revision 1, December 1, 1985**
**Revision 2, January 1, 1992**
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**Revision 6, July 1, 2023**

# MW 1000
# Safety, Maintenance and Construction

**Office of The Deputy Chief Engineer-Track**
**30th Street Station**
**Philadelphia, PA 19104**

Revision 6, July 1st, 2023

**Michael Trosino, Deputy Chief Engineer – Track**

# Mission Statement

It is the policy of the Amtrak Engineering Department to inspect and maintain the safest railroad in the world. The MW 1000 is a key document in realizing that goal.

The MW 1000 details Amtrak's requirements for inspection, maintenance and construction. It is expected that Engineering Department personnel shall receive the classroom and on-the-job training to utilize the MW 1000 to the fullest extent. Understanding the requirements and technical issues contained in the MW 1000 will enable the Track Inspector and Track Foreman to inspect and maintain the world's safest railway.

Commitment to safety while making inspections or repairs is absolutely essential if Amtrak is to have a world class railway.

Quality inspection is key to ensuring that the condition of the property is accurately reported so that repairs or replacements of track structure may be programmed in a systematic and orderly fashion.

The MW 1000 is an interactive document. Its development involved many man-hours and input of many individuals. It is expected that every individual in the Engineering Department that has reason to use this document will constantly strive to offer suggestions and constructive criticism to improve the overall understanding, user friendliness and quality of the MW 1000.

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# The MW 1000 General

The MW 1000 is written for use by Amtrak maintenance-of- way forces in the inspection, maintenance and construction of track. The MW 1000 has three parts:

Part I Limits and Specifications for Track Safety, Maintenance and Construction

Part II Limits and Specifications for Turnout (and Other Trackwork) Safety, Maintenance and Construction *(This Part also includes slips, crossing diamonds, and other special trackwork)*

Part III Limits and Specifications for Miter Rail and Expansion Joint Safety, Maintenance and Construction

Limits in the turnout and miter rail parts are unique and, in some cases, more restrictive, thus superseding the track limits given in Part I. As an example, the gage safety limits for miter rails given in Part III are more restrictive than the gage safety limits for track found in Part I.

Safety limits are limits, once exceeded, that would require the immediate repair of track, slow orders, or removal from service. It is Amtrak's policy to have track that never reaches these limits.

Maintenance is replacing a component of the track structure such as laying new or fit rail or installing ties. Maintenance limits are to be used as a triggering mechanism that prompt maintenance or reconstruction. It is Amtrak's policy to have a track structure that stays between construction and maintenance limits. As the track structure breaks down, maintenance should be programmed before the track reaches the maintenance limits. Maintenance must be executed whenever the maintenance limits are exceeded and completed prior to reaching the safety limits. Whenever possible, track should be repaired or reconstructed to construction limits.

Construction is the complete replacement of track structure from subgrade to top of rail. It should always be the goal to complete construction projects to a zero tolerance from the plans and specifications. This is not always practical given such variables as rail rolling tolerances and manufacturing limitations. Therefore, construction tolerances have been developed.

### Paragraph Number and Lettering

The MW 1000 is composed of three Parts: Track, Turnouts and Miter Rails and Expansion Joints. Each Part contains a "Safety," "Maintenance" and "Construction" subpart. These subparts are further broken down into paragraphs (§) as is the Code of Federal Regulations, 49 CFR Part 213. Wherever possible, the paragraph numbers for similar topics of interest remain the same throughout this document.

The use of the paragraph acronyms and their location in the MW 1000 is summarized below:

| Part | Title | Acronym | Subpart of the MW 1000 |
|---|---|---|---|
| I | Track | None | Safety Limits |
| I | Track | M | Maintenance Limits |
| I | Track | C | Construction Limits |
| II | Turnouts | TO | Safety Limits |
| II | Turnouts | TOM | Maintenance Limits |
| II | Turnouts | TOC | Construction Limits |
| III | Miter Rails and Expansion Joints | MR | Safety Limits |
| III | Miter Rails and Expansion Joints | MRM | Maintenance Limits |
| III | Miter Rails and Expansion Joints | MRC | Construction Limits |

Using the example of gage, the following table lists the location of gage references in the MW 1000:

| Part | Title | Paragraph Number | Paragraph Name | Comments |
|---|---|---|---|---|
| I | Track | §213.53 | Gage | Safety Limits |
| I | Track | §53.0(M) | Gage | Maintenance Limits |
| I | Track | §53.0(C) | Gage | Construction Limits |
| II | Turnouts | §213.53(TO) | Gage | Safety Limits |
| II | Turnouts | §53.0(TOM) | Gage | Maintenance Limits |
| II | Turnouts | §53.0(TOC) | Gage | Construction Limits |
| III | Miter Rails and Expansion Joints | §213.53(MR) | Gage | Safety Limits |
| III | Miter Rails and Expansion Joints | §53.0(MRM) | Gage | Maintenance Limits |
| III | Miter Rails and Expansion Joints | §53.0(MRC) | Gage | Construction Limits |

As shown above, an acronym is used after the paragraph number to designate the location of the paragraph within the MW 1000.

The acronyms "TO" or "MR" indicate that the paragraph is found in the Turnout or Miter Rail and Expansion Joint Parts, respectively. The acronyms "M" or "C" indicate that the paragraph is maintenance or construction related.

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**National Railroad Passenger Corporation**

# PART I

# LIMITS AND SPECIFICATIONS FOR TRACK SAFETY, MAINTENANCE AND CONSTRUCTION

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## SUBPARTS A-G

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## LIMITS AND SPECIFICATIONS FOR TRACK SAFETY

## SUBPARTS A-G

### Track Classes 1-9

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**Subparts A-G**
**Track Classes 1-9**
**Subpart A/G1 — General**

### §213.1 & §213.01 Scope of Subpart (FRA 213.1 & 213.301)

(a) Safety limits are limits, once passed, that would require the immediate repair of track, slow orders, or removal from service. It is Amtrak's policy to have track that never reaches these limits.

(b) In the case where differences may exist between these standards and those prescribed in 49 CFR Part 213 (FRA Track Safety Standards), the more restrictive shall apply.

(c) Part 1 applies to Track Classes 1 through 9 that are required to support the passage of qualified flanged wheel, rail equipment operating at speeds up to 220 MPH.

(d) The Safety subpart prescribes minimum safety requirements and limits for control of the condition of tracks, owned or leased, that are maintained by the National Railroad Passenger Corporation (Amtrak).

(e) These requirements and limits apply where one of the described track conditions is found to exist at a single location. Where a combination of two or more of these conditions is found to exist at the same location, even though none are individually beyond the safety limits, judgment must be used to determine the extent to which such combinations may require remedial action to provide for safe operations over that track.

### §213.3 & §213.03 Application (FRA 213.3)

(a) Part I applies to all tracks, Part II applies to all turnouts, and Part III applies to all miter rails maintained by Amtrak.

(b) This Part applies to all tracks that are used by Amtrak as part of its operating facilities, including yards, shops and other facilities.

### §213.4 Excepted Track (FRA 213.4)

The Deputy Chief Engineer-Track may designate a segment of track as excepted track provided that:

(a) The segment is identified in the timetable, special instructions, general order, or other appropriate records which are available for inspection during regular business hours.

(b) The identified segment is not located within 30' of an adjacent track which can be subjected to simultaneous use at speeds in excess of 10 MPH.

(c) The identified segment is inspected in accordance with §213.233(c) (Federal Railroad Administration (FRA) §213.235) at the frequency specified for Track Class 1.

(d) The identified segment of track is not located on a bridge, including the track approaching the bridge for 100' on either side, or located on a public street or highway, if railroad cars containing commodities required to be placarded by the Hazardous Materials Regulations (49 Code of Federal Regulations (CFR) Part 172), are moved over the track.

(e) Operations on the identified segment are subject to the following conditions:

    (1) No train shall be operated at speeds in excess of 10 MPH.

    (2) No occupied passenger train shall be operated.

    (3) No freight train shall be operated that contains more than five cars required to be placarded by the Hazardous Materials Regulations (49 CFR Part 172).

(4) The gage on excepted track must not be more than 58-1/4".

(f) The Division Engineer must advise the appropriate FRA Regional Office at least 10 days prior to removal of a segment of track from excepted status.

(g) The Deputy Chief Engineer-Track shall be notified of all changes in the status of excepted track.

### §213.5 & §213.05 Responsibility for Compliance (FRA 213.5 & 213.303)

When it is known by track supervision, or track supervision has responsible notice that a track does not comply with any requirements of Part I, II, or, III, the following action must be taken:

(a) Make initial notification (non-class-specific defects). See §213.22.

(b) Repair or improve the track.

(c) Reduce the operating speed to within a range for which the track does comply.

(d) Place the track out of service.

### §213.6 & §213.06 Protection

(a) Protection shall be provided for any track that is considered not satisfactory for the passage of trains at the maximum speed permitted, including placing an appropriate temporary speed restriction and notification of the Block Station and/or Train Dispatcher.

(b) Portions of track on which temporary speed restrictions have been placed are to be indicated by temporary signs or flags in accordance with applicable operating rules, see NORAC Rule 278 and 296 (a through d), and GCOR rule 5.4.

(1) For temporary restrictions that are expected to exceed 8 hours, temporary signs must be installed within 8 hours from the time of notifying the Block Operator, Train Dispatcher or Centralized Electrification Traffic Control (CETC).

(2) Temporary signs are to be placed to give the greatest practical unobstructed view, considering alignment and other local physical conditions. Surfaces of signs must be kept clean to preserve their reflecting ability.

(3) Temporary speed signs indicating slow order areas are to be erected in both directions of traffic, except on tracks where trains operating in the reverse direction are required by timetable to operate at a slower speed than the slow ordered speed. All signs will be placed facing traffic at right angle to, and to the right of, and adjacent to the track to be protected. All numerical Approach speed limit signs must be posted indicating the slow ordered speed for Passenger and if applicable Freight speeds. Installing and removing temporary speed signs or shall be done in the following sequence:

i. Temporary speed signs will be installed in the following sequence: Resume speed sign at the end of the slow order area. Approach speed limit sign to be placed at the proper braking distance from the beginning of the slow order area. See MW 1000 Appendix C. Speed limit sign to be placed at the beginning of the slow order area.

ii. Temporary speed signs will be removed in the following sequence: Speed limit sign, Approach speed limit sign, then Resume speed sign.

(4) In application of Rule 278 in NORAC,

i. For descending grades, the distances in the table should be increased by the amounts indicated in Appendix C. In addition, the "Distance from Approach Speed Signs to Speed Limit Signs and Stop Signs" will be placed in accordance with tables in Appendix C.

ii. Timetable Speeds governing passenger as well as freight movements must be determined for the territory involved. Distance Table for Braking must then be used for both types of traffic and the greater distance utilized for the placement of approach speed limit signs.

iii. Grades for territory involved are indicated on the bottom of each page of the Amtrak Program / Track Charts.

iv. Temporary speed signs and must be placed in accordance with EP 1904 and Standard Plan AM 78850.

(5) For flag placement in GCOR, follow rule 5.4.

(6) Signs and Flags must be removed when restriction is not in effect. Bagging (covering) of speed signs is not authorized.

### §213.7 & §213.07 Designation of Qualified Persons to Supervise Certain Renewals and Inspect Track (FRA 213.7 & 213.305)

(a) Competent persons shall be designated to supervise maintenance, restorations, and renewals of track, turnouts and miter rails under traffic conditions. Each person designated must have -

(1) At least:

<table>
<tr><th>Track Classes 1 through 5</th><th>Track Classes 6 through 9</th></tr>
<tr><td>(i) One year of supervisory experience in railroad track maintenance under traffic conditions; or</td><td>(i) Five years of responsible supervisory experience in railroad track maintenance in track Class 4 or higher and the successful completion of a course offered by the employer or by a college level engineering program, supplemented by special on the job training emphasizing the techniques to be employed in the supervision, restoration, and renewal of high-speed track; or</td></tr>
<tr><td rowspan="2">(ii) A combination of supervisory experience in track maintenance and training from an approved course in track maintenance or from a college level educational program related to track maintenance.</td><td>(ii) A combination of at least one year of responsible supervisory experience in track maintenance in Class 4 or higher and the successful completion of a minimum of 80 hours of specialized training in the maintenance of high-speed track provided by the employer or by a college level engineering program, supplemented by special on the job training provided by the employer with emphasis on the maintenance of high-speed track; or</td></tr>
<tr><td>(iii) A combination of at least two years of experience in track maintenance in track Class 4 or higher and the successful completion of a minimum of 120 hours of specialized training in the maintenance of high-speed track provided by the employer or by a college level engineering program supplemented by special on the job training provided by the employer with emphasis on the maintenance of high-speed track.</td></tr>
</table>

(2) Demonstrated that they:

i. Know and understand the requirements of this Part.

ii. Can detect deviations from those requirements.

iii. Can prescribe appropriate remedial action to correct or safely compensate for those deviations.

(3) Written authority to prescribe remedial actions to correct or safely compensate for deviations from the requirements of this Part.

(b) Competent persons shall be designated to inspect track for defects. Each person designated must have -

(1) At least:

| **FRA Track Classes 1 through 5** | **FRA Track Classes 6 through 9** |
|---|---|
| (i) One year of experience in railroad track inspection; or | (i) Five years of responsible experience inspecting track in Track Class 4 or above and the successful completion of a course offered by the employer by a college level engineering program, supplemented by special on the job training emphasizing the techniques to be employed in the inspection of high-speed track; or |
| (ii) A combination of experience in track inspection and training from a course in track inspection or from a college level educational program related to track inspection; | (ii) A combination of at least one year of responsible experience in track inspection in Class 4 or above and the successful completion of a minimum of 80 hours of specialized training in the inspection of high-speed track provided by the employer or by a college level engineering program, supplemented by special on the job training provided by the employer with emphasis on the inspection of high-speed track; or |
| | (iii) A combination of at least two years of experience in track maintenance in Track Class 4 or above and the successful completion of a minimum of 120 hours of specialized training in the inspection of high-speed track provided by the employer or from a college level engineering program, supplemented by special on the job training provided by the employer with emphasis on the inspection of high-speed track. |

(2) Demonstrated that they:

i. Know and understand the requirements of this Part.

ii. Can detect deviations from those requirements.

iii. Can prescribe appropriate remedial action to correct or safely compensate for deviations from the requirements of this Part, pending review by a person designated under paragraph (a) of this section.

(c) With respect to designations under paragraphs (a) and (b) of this section, written records must be maintained of:

(1) Each designation in effect.

(2) The basis for each designation.

(3) Track inspections made by designated persons as required by §213.241. These

records must be kept available for inspection or copying by the FRA during regular business hours.

(d) A person designated under paragraph (a) or (b) of this section shall be qualified annually, given a standard qualification card and carry the card while on duty.

### §213.9 & §213.09 Classes of Track: Operating Speed Limits (FRA 213.9 & 213.307)

(a) Maximum allowable operating speeds for designated classes of track are:

| Over track that meets all of the requirements prescribed in this Part for: | The maximum allowable operating speed for freight trains (MPH): | The maximum allowable operating speed for passenger trains (MPH): |
|---|---|---|
| Class 1 | 10 | 15 |
| Class 2 | 25 | 30 |
| Class 3 | 40 | 60 |
| Class 4 | 60 | 80 |
| Class 5 | 80 | 90 |
| Class 6 | - | 110 |
| Class 7 | - | 125 |
| Class 8 | - | 160 |
| Class 9 | - | 220 |

(b) If a segment of track does not meet all of the requirements for its intended class, it is reclassified to the next lowest class of track for which it meets all of the requirements of this Part. However, if the segment of track does not at least meet the requirements for Class 1 track, operations may continue at Class 1 speeds for a period of not more than 30 days without bringing the track into compliance, under the authority of a person designated under §213.7(a), who has at least one year of supervisory experience in railroad track maintenance, after that person determines that operations may safely continue and subject to any limiting conditions specified by such person.

(c) Maximum timetable operating speeds will be designated by the Deputy Chief Engineer-Track.

(d) Operating speeds in excess of 125 MPH are authorized by this part only in conjunction with FRA regulatory approval addressing other safety issues presented by the railroad system.

### §213.11 & §213.011 Restoration or Renewal of Track Under Traffic Conditions (FRA 213.11 & 213.309)

If, during a period of restoration or renewal, track is under traffic conditions and does not meet all of the requirements prescribed in this Part, the work on the track must be under the continuous supervision of a person designated under §213.7 who has at least one year of supervisory experience in railroad track maintenance, and subject to any limiting conditions specified by such person. The term "continuous supervision" as used in this section means the physical presence of that person at a job site. However, since the work may be performed over a large area, it is not necessary that each phase of the work be done under the visual supervision of that person.

(a) Restoration or renewal of track under traffic conditions is limited to the replacement of worn, broken, or missing components or fastenings that do not affect the safe passage of trains.

(b) The following activities are expressly prohibited under traffic conditions:

    (1) Any work that interrupts rail continuity, e.g., joint bar replacement or rail replacement.

    (2) Any work that adversely affects the lateral or vertical stability of the track with the exception of spot tamping, an isolated condition where not more than 15 lineal feet of track are involved at any one time and the ambient air temperature is within the limits prescribed in Amtrak's Procedures for the Installation, Adjustment, Maintenance, and Inspection of CWR.

    (3) Removal and replacement of the rail fastenings on more than one tie at a time within 15'.

### §213.13 & §213.013 Measuring Track Not Under Load (FRA 213.13 & 213.311)

When track, not under load, is measured to determine compliance with the requirements of Part I, II, and III, and rail movement under load is apparent, that amount of apparent rail movement must be added to the measurements taken.

### §213.14 & §213.014 Application of requirements to curved track (FRA 213.14 & 213.313)

Unless otherwise provided in this part, requirements specified for curved track only apply to track having a curvature greater than 0.25 degree (0º-15').

### §213.15 & §213.015 Penalties (FRA 213.15)

(a) If any requirement prescribed in Part I, II, or III, is violated, the railroad and its employees may be subject to a civil penalty by the FRA.

(b) Any person who knowingly and willfully falsifies a record or report required by this Part may be subject to criminal penalties.

(c) For the purpose of this section, each day a violation persists is treated as a separate offense.

### §213.17 & §213.017 Waivers (FRA 213.17 & 213.317)

The Deputy Chief Engineer-Track may petition the FRA for a waiver from any or all requirements prescribed Part I, II, or III.

### §213.18 & §218.018 Quality Control

(a) It is the policy of the Amtrak Engineering Department to provide complete and timely track inspection reports which adequately describe the condition of track.

(b) The Track Inspector is responsible for the overall quality and completeness of the inspection performed.

(c) Track inspections shall be performed in accordance with appropriate Engineering Practices and the MW 1000.

(d) The Track Supervisor, Assistant Division Engineer and Division Engineer shall review track inspections and make track inspection audits to ensure quality, consistency and adherence to Engineering Practices.

(e) Track inspection reports that are deficient shall be brought to the attention of the Track Inspector.

(f) The Track Supervisor or Assistant Division Engineer shall provide necessary guidance and direction to correct any deficiencies noted in track inspection reports.

(g) The Track Supervisor or Assistant Division Engineer shall make additional spot checks or audits, as required, to ensure that track inspection reports reflect existing track conditions.

(h) Division Officers and Track Inspectors are encouraged to make recommendations to the Division Engineer or Deputy Chief Engineer-Track as to required modifications to methods, procedures and practices to improve the overall quality of track inspection.

**§213.19 Information Collection (FRA 213.19)**

Refer to 49 CFR §213.19.

**§213.20 & §213.020 Track Inspection Measurements**

(a) The Track Inspector, when making an inspection of track, must make measurements to ensure that the track meets or exceeds the safety limits given in this Part.

(b) When the measurements taken do not comply with the requirements of this Part, then the inspector must take the action as given in §213.5 and §213.05.

(c) Deviations in track that do not comply with the limits in this Part are track defects and are to be recorded.

(d) Deviations that do not comply with the limits in this Part are class-specific or non-class-specific defects.

**§213.21 & §213.021 Class-Specific Defects**

(a) Paragraphs contained in Subparts B, C, D, E, and G of this Part may or may not have specific limits that are directly associated with a class of track.

(b) Deviations from this Part that are both categorized by track class and exceed the allowable limits for that track class are class-specific defects.

(c) Class-specific defects in track that are identified by the inspector shall be handled by that inspector in accordance with §213.5.

**§213.22 & §213.022 Non-Class-Specific Defects**

(a) Deviations from this Part that are not categorized by (or have a direct correlation to) track class are non-class- specific defects.

(b) Generally, there are two types of non-class-specific defects, non-hazardous and those that present a hazard.

(c) Although both types of defects are reported, the remedial action as required in §213.5 will be different depending on severity and circumstance of the defect.

(d) Non-hazardous defects require no restriction, but action must be taken within 30 days of initial reporting. If action in the form of repair is not taken within 30 days, judgment must be used to determine the extent to which such conditions may be permitted to exist and the appropriate remedial action taken.

    (1) For example, a section of track has vegetation overgrowth that extends 1 mile in length along the track side, but only in some locations the overgrowth is extreme to the point of becoming a defect. Although good maintenance practices would require cutting back the vegetation in the entire area, the initial remedial action needed to comply with track safety standards is to cut back the vegetation in the areas that require immediate action. At another location, a mud spot exists that

does not compromise geometry standards but does constitute a drainage defect. Sound maintenance practices require that the track be undercut; in this case the initial remedial action is to clean the ballast section releasing the standing water, by cribbing, shoulder striping and replacement, etc.

(e) Hazardous defects require appropriate remedial action be taken immediately based on the specific circumstances involved or any other limiting track conditions. Appropriate remedial action must be in the form of immediate field repairs, a speed restriction, or removal of the track from service, depending on severity of defect.

(f) The inspector must consider all non-class-specific defects in the context of the specific circumstances involved at the time of inspection. The existence of a non-class-specific defect under one set of circumstances may not be serious, while the identical condition under other circumstances may constitute a serious safety concern and require immediate protection.

(g) Although some non-class-specific defects may not present an immediate hazard, they may become more hazardous with additional train traffic. Therefore, it is important for the inspector to record these defects so that they will not be left unrepaired.

(h) All defects must be reported in the defect section that requires initial notification, immediate repairs or protective action of the Daily Track Inspection Report as defects not conditions. In no case can any defect remain in this section of the report for greater than 30 days.

(i) Examples of possible non-class-specific defects are given below:

(1) Drainage: Drainage or water-carrying facilities obstructed by debris, vegetation and/or silt may not require immediate action other than reporting the defect. Uncontrolled water undercutting a track structure or embankment requires prompt remedial action.

(2) Vegetation: Patches of vegetation that brush the undersides of rolling stock may not be an immediate hazard, but more severe vegetation overgrowth might have the potential of contributing to the injury of an employee looking out of a locomotive cab window or obstructing the view of signals and wayside signs.

(3) Turnouts and track crossings: One or two loose braces, if not at the point of switch, are usually not considered to be an immediate hazard, provided that all other braces are securely in place and supporting the stock rail. On the other hand, three or more consecutively loose braces, especially in high speed territory, must be considered more serious.

One missing cotter pin in a clip bolt, gage plate bolt or switch rod bolt is usually not considered an immediate hazard. On the other hand, a missing cotter pin in a critical location, such as in a connecting rod could have serious consequences.

One loose, worn or missing clip bolt or nut may not be an immediate hazard. On the other hand, one missing nut on a connecting rod is an imminent hazard.

(4) Frog bolts: One or two loose, worn or missing frog bolts out of several would seldom constitute an immediate hazard, provided that all the other frog bolts are secure. However, three or more consecutively loose, worn or missing frog bolts will contribute to deterioration of the structural condition of the frog.

## Subpart B/G2 — Roadbed & Right of Way

### §213.31 Scope of Subpart (FRA 213.31)

This Subpart prescribes minimum requirements for roadbed and areas immediately adjacent to roadbed.

### §213.33 & §213.033 Drainage (FRA 213.33 & 213.319)

(a) Each drainage or other water-carrying facility under or immediately adjacent to the roadbed must be maintained and kept free of obstruction to accommodate expected water flow for the area concerned.

(b) Providing adequate drainage is recognized as first in importance in maintaining a track structure that provides adequate support for the movement of trains and prolongs life of track components. Track inspectors should examine areas where there are apparent problems with surface and alignment to determine if drainage is a contributing factor.

### §213.37 & §213.037 Vegetation (FRA213.37 & 213.321)

Vegetation on railroad property which is on or immediately adjacent to roadbed must be controlled so that it does not:

(a) Become a fire hazard to track-carrying structures.

(b) Obstruct visibility of railroad signs and signals along the right-of-way and at highway-rail crossings.

(c) Interfere with railroad employees performing normal trackside duties.

(d) Prevent proper functioning of signal lines, communication lines, overhead catenary systems and third rail in electrified territories.

(e) Prevent railroad employees from visually inspecting moving equipment from their normal duty stations.

### §213.0359 Track Stiffness (FRA 213.359)

(a) Track shall have a sufficient vertical strength to withstand the maximum vehicle loads generated at maximum permissible train speeds, cant deficiencies and surface defects. For purposes of this section, vertical track strength is defined as the track's capacity to constrain vertical deformations so that the track shall return following maximum load to a configuration in compliance with the track performance and geometry requirements of this subpart.

(b) Track shall have sufficient lateral strength to withstand the maximum thermal and vehicle loads generated at maximum permissible train speeds, cant deficiencies and lateral alignment defects. For purposes of this section lateral track strength is defined as the track capacity to constrain lateral deformations so that track shall return following maximum load to a configuration in compliance with the track performance and geometry requirements of this subpart.

### §213.0361 Right-of-Way (FRA 213.361)

For Track Classes 8 and 9, the Deputy Chief Engineer- Engineering shall develop a right-of-way barrier plan and submit this plan to the FRA for approval.

### §213.0345 Vehicle Qualification Testing (FRA 213.345)

All vehicle types will be qualified for operation for their intended track classes in order to demonstrate that the vehicle dynamic responses to track alignment and geometry variations are within acceptable limits to assure safe operation.

### §213.0347 Automotive or Railroad Crossings At-Grade (FRA 213.347)

(a) There shall be no at grade (level highway crossing, public or private, or rail-to-rail crossings at-grade on Track Classes 8 and 9.

(b) Trains shall not operate Track Class 7 speeds over any track segment having highway-rail crossings unless:

(1) The warning barrier system in place is approved by the FRA for each crossing location.

(2) All elements of that warning / barrier system are functioning.

## Subpart C/G3 — Track Geometry

### §213.51 Scope of Subpart

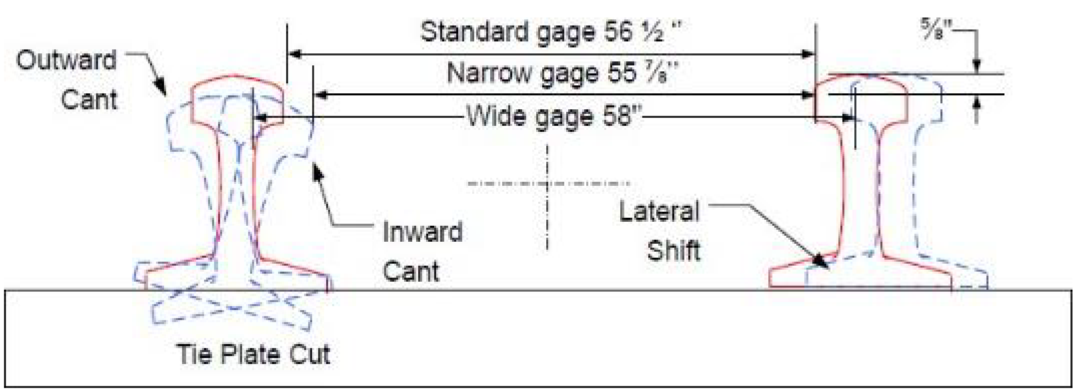
This Subpart prescribes requirements for the gage, alignment, and surface of track, and the superelevation and speed limits on curves.

### §213.53 & §213.053 Gage (FRA 213.53 & 213.323)

(a) Gage is measured between the heads of rails at right angles to the rails in a plane 5/8" below the top of the rail head.

(b) Gage must be within the limits prescribed in the following table:

| Track Class | Minimum (inches) | | Maximum (inches) | | Maximum Change within 31’ (inches) | |
|---|---|---|---|---|---|---|
| | **Safety** | *Maint.* | **Safety** | *Maint.* | **Safety** | *Maint.* |
| 1 | **56** | *56-1/4* | **58** | *57-1/2* | **-** | *1* |
| 2 | **56** | *56-1/4* | **57-3/4** | *57-1/2* | **-** | *1* |
| 3 | **56** | *56-1/4* | **57-3/4** | *57-1/2* | **-** | *3/4* |
| 4 | **56** | *56-1/4* | **57-1/2** | *57-1/4* | **-** | *1/2* |
| 5 | **56** | *56-1/4* | **57-1/2** | *57-1/4* | **-** | *1/2* |
| 6 | **56** | *56-1/4* | **57-1/4** | *57* | **3/4** | *3/8* |
| 7 | **56** | *56-1/4* | **57-1/4** | *57* | **1/2** | *3/8* |
| 8 | **56** | *56-1/4* | **57-1/4** | *57* | **1/2** | *3/8* |
| 9 | **56-1/4** | *56-3/8* | **57-1/4** | *57* | **1/2** | *3/8* |



## §213.55 & §213.055 Alignment (FRA 213.55 & 213.327)

(a) A single alignment deviation from uniformity may not be more than the amount prescribed in the following table:

| Class of Track | | Chord Length | | | | | |
|---|---|---|---|---|---|---|---|
| | | 31’ | | 62’ | | 124’ | |
| | | **Safety** | *Maint.* | **Safety** | *Maint.* | **Safety** | *Maint.* |
| 1 | Tangent | **-** | *-* | **5”** | *3-3/4”* | **-** | *-* |
| | Curve Eu ≤ 5” | **-** | *2-3/4”* | **5”** | *3-3/4”* | **-** | *-* |
| | Curve Eu > 5” | **-** | *1”* | **1-1/4”** | *1”* | **-** | *-* |
| 2 | Tangent | **-** | *-* | **3”** | *2-1/4”* | **-** | *-* |
| | Curve Eu ≤ 5” | **-** | *1-1/2”* | **3”** | *2-1/4”* | **-** | *-* |
| | Curve Eu > 5” | **-** | *3/4”* | **1-1/4”** | *1”* | **-** | *-* |
| 3 | Tangent | **-** | *-* | **1-3/4”** | *1-1/4”* | **-** | *-* |
| | Curve Eu ≤ 5” | **1-1/4”** | *7/8”* | **1-3/4”** | *1-1/4”* | **-** | *-* |
| | Curve Eu > 5” | **3/4”** | *5/8”* | **1-1/4”** | *1”* | **-** | *-* |
| 4 | Tangent | **-** | *-* | **1-1/2”** | *1”* | **-** | *-* |
| | Curve Eu ≤ 5” | **1”** | *3/4”* | **1-1/2”** | *1”* | **-** | *-* |
| | Curve Eu > 5” | **3/4”** | *5/8”* | **7/8”** | *3/4”* | **-** | *-* |
| 5 | Tangent | **-** | *-* | **3/4”** | *1/2”* | **-** | *-* |
| | Curve Eu ≤ 5” | **1/2”** | *3/8”* | **5/8”** | *1/2”* | **-** | *-* |
| | Curve Eu > 5” | **1/2”** | *3/8”* | **5/8”** | *1/2”* | **-** | *-* |
| 6 | Tangent | **1/2”** | *3/8”* | **3/4”** | *1/2”* | **1-1/2”** | *1”* |
| | Curve Eu ≤ 5” | **1/2”** | *3/8”* | **5/8”** | *1/2”* | **1-1/2”** | *1”* |
| | Curve Eu > 5” | **1/2”** | *3/8”* | **5/8”** | *1/2”* | **1-1/4”** | *1”* |
| 7 | Tangent | **1/2”** | *3/8”* | **3/4”** | *3/8”* | **1-1/4”** | *7/8”* |
| | Curve Eu ≤ 5” | **1/2”** | *3/8”* | **1/2”** | *3/8”* | **1-1/4”** | *7/8”* |
| | Curve Eu > 5” | **1/2”** | *3/8”* | **1/2”** | *3/8”* | **1”** | *7/8”* |
| 8 | Tangent | **1/2”** | *3/8”* | **3/4”** | *3/8”* | **1”** | *1/2”* |
| | Curve Eu ≤ 5” | **1/2”** | *3/8”* | **1/2”** | *3/8”* | **3/4”** | *1/2”* |
| | Curve Eu > 5” | **1/2”** | *3/8”* | **1/2”** | *3/8”* | **3/4”** | *1/2”* |
| 9 | Tangent | **1/2”** | *3/8”* | **1/2”** | *3/8”* | **3/4”** | *1/2”* |
| | Curve Eu ≤ 5” | **1/2”** | *3/8”* | **1/2”** | *3/8”* | **3/4”** | *1/2”* |
| | Curve Eu > 5” | **1/2”** | *3/8”* | **1/2”** | *3/8”* | **3/4”** | *1/2”* |

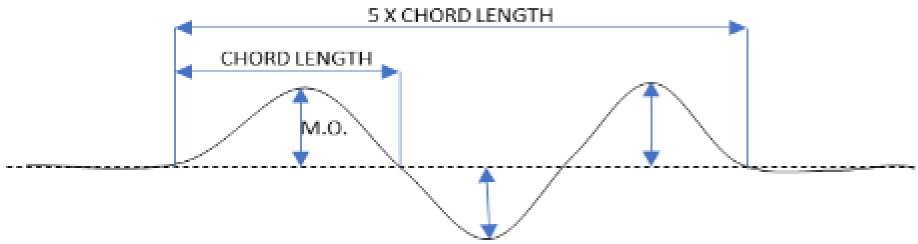
(1) Uniformity at any point along the track is established by averaging the measured mid-chord offset values for nine consecutive points centered around that point spaced according to the following table:

| Chord Length | Spacing |
|---|---|
| 31’ | 7’ 9" |
| 62’ | 15' 6" |
| 124’ | 31' 0" |

(2) The ends of the line or chord must be at points on the gage side of the line rail, 5/8" below the top of the rail head. Use line rail in accordance with §55.1(M).

(3) In track classes 1 through 5, both 31’ and 62’ chord lengths shall be used. In track classes 6 and above 31’, 62’ and 124’ chord lengths shall be used.

(4) On tangent track, either rail may be used as the line rail. However, the same rail shall be used for the full length of that tangential segment of track. See section 213.57 (e) for formula used to calculate $E_u$.




(b) Multiple deviations - Alignment may not deviate from uniformity more than the amount prescribed on the following table for three or more non-overlapping deviations occurring within a distance equal to five times the specified chord length:

| Class of Track | Chord Length | | | | | |
|---|---|---|---|---|---|---|
| | 31’ | | 62’ | | 124’ | |
| | **Safety** | *Maint.* | **Safety** | *Maint.* | **Safety** | *Maint.* |
| 6 | **3/8”** | *1/4”* | **1/2”** | *3/8”* | **1”** | *3/4”* |
| 7 | **3/8”** | *1/4”* | **3/8”** | *1/4”* | **7/8”** | *5/8”* |
| 8 & 9 | **3/8”** | *1/4”* | **3/8”** | *1/4”* | **1/2”** | *3/8”* |

### §213.57 & §213.057 Curves: Superelevation and Speed Limits (FRA 213.57 & 213.329)

(a) The maximum superelevation on the outside rail of a curve may not be more than 8" on Track Classes 1 and 2 and may not be more than 7" on Track Classes 3 - 9. Except as provided in §213.63, the outside rail of a curve may not be lower than the inside rail.

(b) Maximum allowable speeds for various degrees of curvature and amounts of superelevation for passenger trains consisting entirely of designated types of equipment shall be determined by the Deputy Chief Engineer-Track. Speeds will be computed using the following formula:

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

$V_{max}$ = Maximum allowable operating speed (MPH)
$E_a$ = Actual superelevation of the outside rail (inches)[See note 1]
$E_u$ = Underbalance (inches)[See note 2]
$D$ = Degree of curvature (degrees)[See note 3]

[1]Actual superelevation for each 155' track segment in the body of the curve is determined by averaging the elevation for 10 points through the segment at 15’6” spacing. If the curve length is less than 155', average the points through the full length of the body of the curve.

[2]If the actual super-elevation and degree of curvature change because of track degradation, then the actual underbalance for the maximum allowable posted timetable operating speed may be greater than the equipment qualified cant deficiency. For track classes 1 through 5 the actual underbalance for each curve may not exceed the equipment qualified cant deficiency plus one inch, and for track classes 6 through 9 the actual underbalance for each curve may not exceed the equipment qualified cant deficiency plus one-half inch.

[3]Degree of curvature is determined by averaging the degree of curvature over the same track segment as the elevation.

(c) Refer to Appendix B for underbalance charts.

(d) Example: Find the maximum allowable operating speed for a 1°-15' curve with 2-1/2" of actual superelevation ($E_a$) and 3" of underbalance ($E_u$).

Superelevation readings for 10 points are as follows: 2-1/2", 2-1/4", 2-5/8", 2-3/8", 2-3/4", 2-1/2", 2-3/8", 2-1/4", 2-5/8, and 2-3/4.

The 2-1/2" actual superelevation is obtained by averaging the readings taken for 10 points in the curve segment as given in paragraph (b), note 1, above.

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

$$V_{max} = \sqrt{\frac{2.5 + 3.0}{0.0007(1.25)}}$$

$$V_{max} = \sqrt{\frac{5.5}{0.000875}}$$

$$V_{max} = \sqrt{6285.71}$$

$$V_{max} = 79.28$$

$$V_{max} = 79\ MPH\ (See\ Appendix\ B)$$

(e) The maximum allowable operating speed in curves shall not exceed that calculated by using the equipment qualified cant deficiency for underbalance. The Deputy Chief Engineer-Track or designee shall determine the posted timetable speed through curves for each train type.

(f) The variables in the V max formula may be rearranged as follows to calculate actual underbalance to compare to equipment qualified cant deficiency:

$$E_u = 0.0007 \times D \times V_{max}{}^2 - E_a$$

Where $V_{max}$ is the posted timetable speed for the equipment type being evaluated.

### §213.59 & §213.059 Superelevation of Curved Track; Runoff (FRA 213.59)

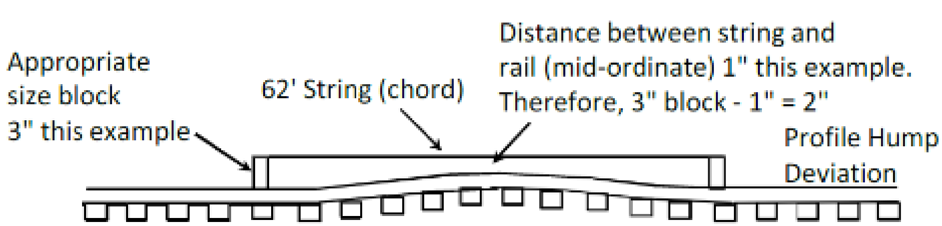
(a) If a curve is elevated, the full elevation shall be provided throughout the curve, unless physical conditions do not permit. If elevation runoff occurs in a curve, the actual minimum elevation shall be used in computing the maximum allowable posted timetable operating speed for that curve under §213.57(b).

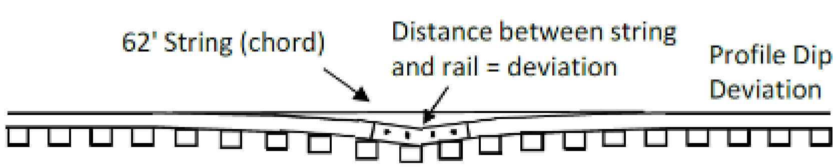
(b) Elevation runoff shall be at a uniform rate, within the limits of track surface deviation prescribed in §213.63, and it shall extend a least the full length of the spirals. If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, part of the runoff may be on tangent track.

## §213.63 & §213.063 Track Surface ([FRA 213.63](#) & [213.331](#))

(a) The surface of track shall be maintained within the limits prescribed in the following tables:

| SINGLE POINT – Deviation from uniform profile on either rail at mid-chord: | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Class of Track** | | **Chord Length** | | | | | |
| | | **31’** | | **62’** | | **124’** | |
| | | **Safety** | *Maint.* | **Safety** | *Maint.* | **Safety** | *Maint.* |
| 1 | Tangent/Curve Eu ≤ 5” | **-** | - | **3”** | *2-1/4”* | **-** | - |
| | Curve Eu > 5” | **-** | - | **2-1/4”** | *1-5/8”* | **-** | - |
| 2 | Tangent/ Curve Eu ≤ 5” | **-** | - | **2-3/4”** | *2”* | **-** | - |
| | Curve Eu > 5” | **-** | - | **2-1/4”** | *1-5/8”* | **-** | - |
| 3 | Tangent/ Curve Eu ≤ 5” | **-** | - | **2-1/4”** | *1-5/8”* | **-** | - |
| | Curve Eu > 5” | **1”** | *3/4”* | **1-3/4”** | *1-3/8”* | **-** | - |
| 4 | Tangent/ Curve Eu ≤ 5” | **-** | - | **2”** | *1-1/2”* | **-** | - |
| | Curve Eu > 5” | **1”** | *3/4”* | **1-1/4”** | *1”* | **-** | - |
| 5 | Tangent/ Curve Eu ≤ 5” | **-** | - | **1-1/4”** | *1”* | **-** | - |
| | Curve Eu > 5” | **1”** | *3/4”* | **1”** | *3/4"* | **-** | - |
| 6 | Tangent/ Curve Eu ≤ 5” | **1”** | *3/4”* | **1”** | *3/4"* | **1-3/4”** | *1-1/4”* |
| | Curve Eu > 5” | **1”** | *3/4”* | **1”** | *3/4"* | **1-1/2”** | *1-1/8”* |
| 7 | Tangent/ Curve Eu ≤ 5” | **1”** | *3/4”* | **1”** | *3/4"* | **1-1/2”** | *1”* |
| | Curve Eu > 5” | **1”** | *3/4"* | **1”** | *3/4"* | **1-1/4”** | *1”* |
| 8 | Tangent/ Curve Eu ≤ 5” | **3/4”** | *1/2”* | **1”** | *3/4"* | **1-1/4”** | *7/8”* |
| | Curve Eu > 5” | **3/4”** | *1/2"* | **1”** | *3/4"* | **1-1/4”** | *7/8”* |
| 9 | Tangent/ Curve Eu ≤ 5” | **1/2"** | *3/8”* | **3/4"** | *1/2"* | **1”** | *7/8”* |
| | Curve Eu > 5” | **1/2"** | *3/8”* | **3/4"** | *1/2"* | **1”** | *7/8”* |



**MULTIPLE DEVIATION – Three or more non-overlapping deviations within five times the chord length, each deviation from uniformity at mid-chord offset may not be more than:**

| Track Class | Chord Length | | | | | |
|---|---|---|---|---|---|---|
| | 31' | | 62' | | 124' | |
| | **Safety** | *Maint* | **Safety** | *Maint* | **Safety** | *Maint* |
| 4 | **-** | *-* | **1-1/2"** | *1"* | **-** | *-* |
| 5 | **-** | *-* | **1"** | *3/4"* | **-** | *-* |
| 6 | **3/4"** | *1/2"* | **3/4"** | *1/2"* | **1-1/4"** | *7/8"* |
| 7 | **3/4"** | *1/2"* | **3/4"** | *1/2"* | **1"** | *3/4"* |
| 8 | **1/2"** | *3/8"* | **3/4"** | *1/2"* | **7/8"** | *5/8"* |
| 9 | **3/8"** | *1/4"* | **1/2"** | *3/8"* | **5/8"** | *5/8"* |

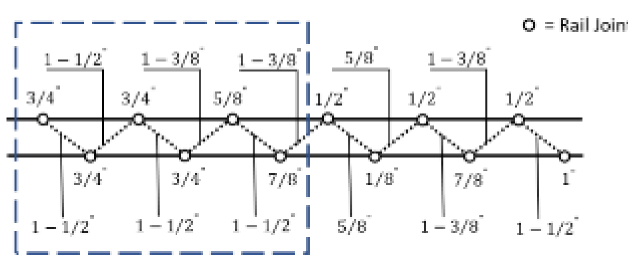
| Class of Track | RUNOFF – in any 31' of the rail at the end of a raise may not be more than: | |
|---|---|---|
| | **Safety** | *Maintenance* |
| 1 | **3-1/2"** | *2-5/8"* |
| 2 | **3"** | *2-1/4"* |
| 3 | **2"** | *1-1/2"* |
| 4 | **1-1/2"** | *1-1/8"* |
| 5-7 | **1"** | *3/4"* |
| 8-9 | **1/2"** | *3/8"* |

| Class of Track | Reverse Elevation in Curves | |
|---|---|---|
| | **Safety** | *Maintenance* |
| 1 | **3"** | *2-1/4"* |
| 2 | **2"** | *1-1/2"* |
| 3 | **1-3/4"** | *1-3/8"* |
| 4 | **1-1/4"** | *1-1/4"* |
| 5 | **1"** | *1"* |
| 6-9 | **1/2"** | *1/2"* |

**CROSSLEVEL & WARP**

| Class of Track | CROSSLEVEL in Tangent | | WARP – Difference in Crosslevel between any two points (Tangent, Spiral or Curve) within: | | | |
|---|---|---|---|---|---|---|
| | | | 10' (short warp) | | 62' [1] | |
| | **Safety** | *Maint* | **Safety** | *Maint* | **Safety** | *Maint* |
| 1 | **3"** | *2-1/4"* | **1-1/4"** | *1"* | **3"** | *2-1/4"* |
| 2 | **2"** | *1-1/2"* | **1-1/4"** | *1"* | **2-1/4"** | *1-5/8"* |
| 3 | **1-3/4"** | *1-1/4"* | **1-1/4"** | *1"* | **2"** | *1-1/2"* |
| 4 | **1-1/4"** | *1"* | **1-1/4"** | *1"* | **1-3/4"** | *1-1/4"* |
| 5 | **1"** | *3/4"* | **1-1/4"** | *1"* | **1-1/2"** | *1-1/8"* |
| 6-7 | **1"** | *3/4"* | **1"** | *3/4"* | **1-1/2"** | *1"* |
| 8 | **1"** | *1/2"* | **1"** | *3/4"* | **1-1/4"** | *1"* |
| 9 | **1"** | *3/4"* | **3/4"** | *3/4"* | **1"** | *1"* |

[1]Except as limited by §213.57(a), where the elevation at any point in a curve equals or exceeds 6", the difference in crosslevel within 62' between that point and a point with greater elevation may not be more than 1-1/2". (Effective one year after effective date of this rule) However, to control harmonics on jointed track with staggered joints, the crosslevel differences shall not exceed 1-1/4" in all of 6 consecutive pairs of joints, as created by 7 low joints. (See diagram below.) Track with joints staggered less than 10' shall not be considered as having staggered joints. Joints within the 7 low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.




The worst warp is 1-1/2" which is acceptable for Class 6 but six consecutive pair of Joints have a difference that exceed 1-1/4". Therefore, the track must be reduced to Class 1.

**§213.65 & §213.065 Combined Track Alignment and Surface Deviations (FRA 213.65 & 213.332)**

(a) This section applies to any curved track where operations are conducted at a qualified cant deficiency, Eu, greater than 5 inches, and to all Class 9 track, either curved or tangent.

(b) For the conditions defined in paragraph (a) of this section, the combination of alignment and surface deviations for the same chord length on the outside rail in a curve and on any of the two rails of a tangent section, as measured by a TGMS, shall comply with the following formula: On any curved track where operations are conducted at a qualified cant deficiency, Eu, greater than 5 inches, the combination of alignment and surface deviations for the same chord length on the outside rail in the curve, as measured by a TGMS, shall comply with the following formula:

$$\frac{3}{4} * \left|\frac{A_m}{A_L} + \frac{S_m}{S_L}\right| \leq 1$$

Where—

$A_m$ = measured alignment deviation from uniformity (outward is positive, inward is negative).

$A_L$ = allowable alignment limit as per § 213.55(b) (always positive) for the class of track.

$S_m$ = measured profile deviation from uniformity (down is positive, up is negative).

$S_L$ = allowable profile limit as per § 213.63(b) (always positive) for the class of track.

$\left|\frac{A_m}{A_L} + \frac{S_m}{S_L}\right|$ = the absolute (positive) value of the result of $\frac{A_m}{A_L} + \frac{S_m}{S_L}$

**§213.66 & §213.066 Ride Quality (Accelerometer)**

The following action is required after measurement of lateral and vertical acceleration by an on-board ride quality computer (accelerometer).

| Accelerations | Action |
|---|---|
| .25g - .49g Lateral<br>.40g - .60g Vertical | Field verify and correct deviations from standard as required. |
| .50g - .64g Lateral<br>.61g - .99g Vertical | Restrict speed to next lower class of track below that for the maximum allowable timetable speed, field verify and correct deviations from standard as required. |
| .65g and greater Lateral<br>1.0g and greater Vertical | Restrict speed to next lower class of track below that for the actual speed operated by the equipment at the time the exception was found, field verify and correct deviations from standard as required. |

**§213.070 Automated Vehicle Inspection Systems (FRA 213.333)**

(a) Unless otherwise required by FRA conditional approval for the operation of specific types of equipment in the circumstances of the infrastructure; qualifications, procedures, and operation of Automated Vehicle Inspection Systems shall be in accordance with their respective Engineering Practices and 49 CFR §213.333. Where conflict exists amongst the requirements listed above, the more restrictive shall apply. These systems consist of the following:

(1) Gage Restraint Measurement System, EP 2002

(2) Track Geometry Measurement Systems, EP 2007

(3) Remote Monitoring System Inspections, EP 2015

## Subpart D/G4 — Track Structure

### §213.101 Scope of Subpart (FRA 213.101)

This Subpart prescribes minimum requirements for ballast, crossties, track components, and the physical conditions of rails.

### §213.103 & §213.0103 Ballast; General (FRA 213.103 & 213.334)

(a) Unless it is otherwise structurally supported, all tracks must be supported by material that will:

(1) Transmit and distribute the load of the track and railroad rolling equipment to the subgrade.

(2) Restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by railroad rolling equipment and thermal stress exerted by the rails.

(3) Provide drainage for the track structure.

(4) Facilitate maintenance of track crosslevel, surface, and alignment.

(b) A speed restriction of 30 MPH or less depending on severity must be placed where there is insufficient ballast to provide a stable track.

### §213.109 & §213.0109 Crossties (FRA 213.109 & 213.335)

(a) Crossties shall be made of a material to which rail can be securely fastened. The material must be capable of holding the rails to proper gage, surface, and alignment, and of transmitting wheel loads from the rails to the ballast and roadbed.

(b) Each 39' segment of track shall have:

(1) A sufficient number of crossties that in combination, provide effective support that:

(i) Holds gage within the limits prescribed in §213.53(b).

(ii) Maintains surface within the limits prescribed in §213.63.

(iii) Maintains alignment within the limits prescribed in §213.55.

(2) The minimum number and type of crossties specified in this section effectively distributed to support the entire segment.

(3) At least one crosstie of the type specified in this section that is located at a joint location as specified in paragraph (e) of this section.

| WOOD TIE REQUIREMENTS<br>Each 39’ segment of track shall have the minimum number of effective ties indicated below | | | | |
|---|---|---|---|---|
| **Class of Track** | **Tangent track and curves less than or equal to 2°** | **Turnouts and curved track over 2°** | **Maximum distance between effective ties (center to center)** | **Maximum number of successive defective ties (normal spacing)** |
| 1 | 5 | 6 | 100” | 3 |
| 2 | 8 | 9 | 74” | 2 |
| 3 | 8 | 10 | 74” | 2 |
| 4 | 12 | 14 | 60” | 2 |
| 5 | 12 | 14 | 50” | 1 |
| 6 | 14 | 14 | 50” | 1 |
| 7-9 | 18 | 18 | * | 1 |

**In Track Class 7, 8 and 9 there shall be at least three consecutive effective ties on both sides of a defective tie.*

(c) A wood crosstie (including bridge timbers) counted to satisfy the requirements of this section shall not be:

(1) Broken through.

(2) Split or otherwise impaired to the extent that the crossties will allow the ballast to work through or will not hold spikes or rail fastening systems.

(3) So deteriorated that the tie plate or base of rail can move laterally more than 1/2" in Track Classes 1 through 5 or 3/8” in Track Classes 6 through 9 relative to the crosstie.

(4) Cut by the tie plate through more than 40% of the tie’s thickness.

(5) Not fastened as required by §213.127.

| **CONCRETE TIE REQUIREMENTS**<br>**Each 39’ segment of track shall have the minimum number of effective ties indicated below**<br>(Note: For the purposes of evaluation, a 39’ segment of track is considered to consist of nineteen (19) concrete ties.) | | | | |
|---|---|---|---|---|
| **Class of Track** | **Tangent track and curves less than or equal to 2°** | **Turnout and curved track over 2°** | **Maximum Number of successive defective ties** | **Minimum Number of effective ties on both sides of defective tie(s)** |
| 1 | 5 | 6 | 3 | 1 |
| 2 | 8 | 9 | 3 | 1 |
| 3 | 8 | 10 | 2 | 1 |
| 4 | 12 | 14 | 2 | 2 |
| 5 | 12 | 14 | 2 | 2 |
| 6 | 14 | 14 | 2 | 2 |
| 7-9 | 16 | 18 | 1 | 3 |

(d) A concrete crosstie counted to satisfy the requirements this paragraph shall not be:

(1) So deteriorated that the prestress strands are ineffective or withdrawn into the tie at one end and the tie exhibits structural cracks in the rail seat or in the gage of track.

(2) Configured with less than two fasteners on the same rail except at insulated joints where application would short circuit signaling systems.

(3) So deteriorated or broken off in the vicinity of the rail fastener such that the fastener assembly may pull out or the move laterally more than 3/8 inch relative to the crosstie.

(4) So deteriorated the fastener base plate or base of rail can move laterally more than 3/8 inch relative to the crossties.

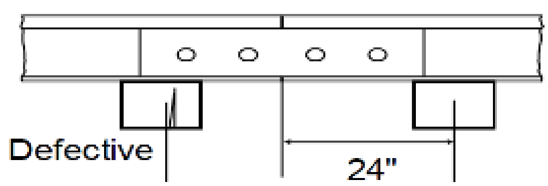
(5) So deteriorated at any point in the rail seat that the abrasion is sufficiently deep to cause loss of rail fastener toeload or in any case where abrasion is more than 1/2”.

(6) Completely broken through

(e) Track Classes 1 and 2 shall have one effective crosstie whose centerline is within 24" of the center of joint, and Track Classes 3-6 shall have one effective crosstie whose centerline is within 18" of the center of joint or two crossties whose centerlines are within 24" either side of the center of joint. Class 7, 8, and 9 track shall have two non-defective ties within 24 inches each side of the rail joint. The relative position of these ties is described in the following diagrams.

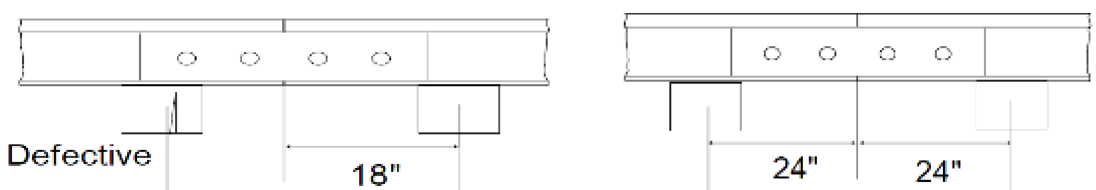
| JOINT TIE REQUIREMENTS<br>Each rail joint shall have the minimum number of effective crosstie(s) who's centerline is within the following distances as indicated below. | |
|---|---|
| **Class of Track** | **Maximum distance from center of a Rail Joint:** |
| 1 - 2 | One effective crosstie within 24" |
| 3 - 6 | One effective crosstie within 18" **OR** Two effective crossties within 24" |
| 7 - 9 | Two effective crossties, one on each side of the rail joint, within 24" |

**Track Classes 1 and 2**



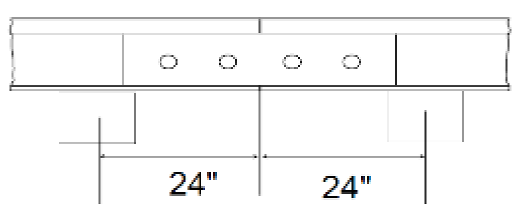

Each rail joint in Track Classes 1 and 2 shall be supported by at least one effective crosstie whose centerline is within 24" of the center of the joint specified in paragraphs (c), (d) and (e) of this section.

**Track Classes 3 - 6**




Each rail joint in Track Classes 3-6 shall be supported by either at least one effective crosstie whose centerline is within 18" of the center of the joint specified in paragraphs (c), (d) and (e) of this section or two crossties, one on each side of the rail joint, whose centerlines are within 24" of the center of the rail joint, shown above.

**Track Classes 7 - 9**




Class 7, 8, and 9 track shall have two effective crossties, one on each side of the rail joint, whose centerlines are within 24" of the center of the rail joint, shown above.

(f) For track constructed without crossties, such as slab track, track connected directly to bridge structural components and track over servicing pits, the track structure must meet the requirements of paragraphs (b)(1)(i), (ii), and (iii).

(g) New technology ties such as composite, hollow steel, etc. shall be considered other than concrete ties and must follow the requirements for wood crossties.

(h) Ties damaged by derailment will require frequent close inspection.

(i) Crossties may not be interlaced to take the place of switch ties except in an emergency or a temporary turnout installation.

### §213.110 Gage Restraint Measurement Systems (FRA 213.110)

Refer to 49 CFR 213.110.

### §213.113 & §213.0113 Defective Rails (FRA 213.113 & 213.337)

When it is known that a rail in a track contains any of the defects listed in the following table, a person designated under §213.7(a) or (b) shall not permit operations over that rail until:

(1) The defective rail is replaced and classified in accordance with §113.3(M).

(2) The remedial action prescribed in the following table is initiated.

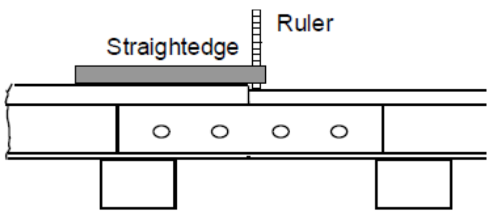
| Defect | Size | Remedial Action |
|---|---|---|
| **Compound Fissure** (TDC) | 5% – 69% | 30 mph restriction |
| | 70 – 99% | 10 mph restriction and visual inspection every 24 hours |
| | 100% | Visual supervision of each movement over defective rail at a speed not to exceed 4 mph |
| **Transverse Fissure** (TDT)<br>**Detail Fracture** (TDD)<br>**Engine Burn Fracture** (EBF)<br>**Defective Weld** (DWF)/(DWG)/(DWP) | 5% – 24% | Apply joint bars bolted through outermost holes and 50 mph restriction **OR**<br>If joint bars cannot be applied:<br>30 mph restriction for 10 days<br>10 mph restriction on the 11th day |
| | 25% – 59% | Apply joint bars bolted through outermost holes and 50 mph restriction **OR**<br>If joint bars cannot be applied:<br>30 mph restriction for 7 days<br>10 mph restriction on the 8th day |
| | 60% – 99% | 10 mph restriction and visual inspection every 24 hours<br>**OR**<br>Apply joint bars bolted through outermost holes and 50 mph restriction |
| | 100% | Visual supervision of each movement over defective rail at a speed not to exceed 4 mph<br>**OR**<br>Apply joint bars bolted through outermost holes and 50 mph restriction |
| **Horizontal Split Head** (HSH)<br>**Vertical Split Head** (VSH)<br>**Split Web** (SWO/SWJ)<br>**Piped Rail** (PRO/PRJ)<br>**Head-Web Separation** (HWO/HWJ)<br>**Longitudinal Defective Weld** (DWF)/(DWG)/(DWP) | 1” – 1.99” | 50 mph restriction **AND**<br>Internal rail inspection within 90 days – if rail is not re-inspected within 90 days, restrict to Class 2 |
| | 2” – 3.99” | 30 mph restriction **AND**<br>Internal rail inspection within 30 days – if rail is not re-inspected within 30 days, restrict to Class 2 |
| | 4” or more | Limit speed as authorized by 213.7(a) qualified- in no case exceed 30 mph |
| | Breakout in railhead | Visual supervision of each movement over defective rail at a speed not to exceed 4 mph |

| Defect | Size | Remedial Action |
|---|---|---|
| **Bolt Hole Crack** (BHO/BHJ) **not to be used for miter rails – see 213.113 (MR)* | 0.5" – 0.99" | 50 mph restriction **AND**<br>Internal rail inspection within 90 days – if rail is not re-inspected within 90 days, restrict to Class 2 |
| | 1" – 1.49" | 50 mph restriction **AND**<br>Internal rail inspection within 30 days – if rail is not re-inspected within 30 days, restrict to Class 2 |
| | 1.5" or more | Limit speed as authorized by 213.7(a) qualified- in no case exceed 30 mph |
| | Breakout in railhead | Visual supervision of each movement over defective rail at a speed not to exceed 4 mph |
| **Broken Base** (BBO/BBJ) | 1" – 5.99" | Apply joint bars bolted through outermost holes and 50 mph restriction<br>**OR**<br>If joint bars cannot be applied:<br>30 mph restriction for 7 days<br>10 mph restriction on the 8th day |
| | 6" or more | Visual supervision of each movement over defective rail at a speed not to exceed 4 mph<br>**OR**<br>30 mph restriction and apply joint bars |
| **Moon-shaped Broken Base resulting from a derailment** (BBO/BBJ) | 6" – 12" in length **AND** Less than 1/3 the rail base width | Apply joint bars bolted through outermost holes and 50 mph restriction **OR**<br>If joint bars cannot be applied:<br>30 mph restriction for 7 days<br>10 mph restriction on the 8th day |
| **Ordinary Break** | N/A | Visual supervision of each movement over defective rail<br>**OR**<br>Apply joint bars |
| **Damaged Rail** | N/A | Apply joint bars bolted through outermost holes and 50 mph restriction **OR**<br>If joint bars cannot be applied:<br>30 mph restriction for 10 days<br>10 mph restriction on the 11th day |
| **Flattened Rail Crushed Head** | 3/8" or more in depth **AND** 8" or more in length | 50 mph restriction |
| **No Test** | N/A | See 213.237 / 213.0237 |

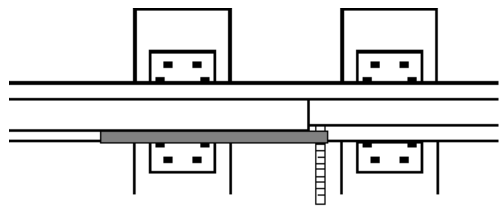
### §213.115 & §213.0115 Rail End Mismatch (FRA 213.115 & 213.349)

Any mismatch of rails at joints may not be more than that prescribed in the following table:

| Track Class | On the HEAD of the rail ends (inch) | | On the GAGE side of the rail ends (inch) | |
|---|---|---|---|---|
| | **Safety Limits** | *Maint. Limits* | **Safety Limits** | *Maint. Limits* |
| 1 | **1/4** | *1/8* | **1/4** | *1/8* |
| 2 | **1/4** | *1/8* | **3/16** | *1/8* |
| 3 | **3/16** | *1/8* | **3/16** | *1/8* |
| 4-5 | **1/8** | *3/32* | **1/8** | *3/32* |
| 6-9 | **1/8** | *1/16* | **1/8** | *1/16* |




Tread mismatch



Gage mismatch

### §213.117 & §213.0117 Rail End Batter

(a) Rail end batter is the depth of depression at 1/2" from the end of the rail. It is measured by placing an 18" straightedge on the head of the rail end, without bridging the joint and measuring the distance between the bottom of the straightedge and the top of the rail end.

(b) Rail end batter may not be more than that prescribed by the following table:

| Track Class | Safety Limits |
|---|---|
| 1 | **1/2"** |
| 2-3 | **3/8”** |
| 4 | **1/4”** |
| 5-9 | **1/8”** |

### §213.118 Continuous Welded Rail (CWR); plan review and approval (FRA 213.118)

Refer to 49 CFR 213.118.

### §213.119 Continuous Welded Rail (CWR); General (FRA 213.119 & 213.343)

CWR shall be inspected, installed, and maintained in accordance with Amtrak Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR as required by 49 CFR §213.118.

### §213.121 & §213.0121 Rail Joints (FRA 213.121 & 213.351)

(a) Each rail joint, insulated joint, and compromise joint must be of a structurally sound design and dimensions for the rail on which it is applied.

(b) If a joint bar in Track Classes 3-9 is cracked, broken (other than between the middle two bolt holes) or because of wear allows excessive vertical movement of either rail when all bolts are tight, the track must be protected by a 25 MPH (F) and 30 MPH (P) speed restriction until the bar is replaced.

(c) For a single cracked or broken bar between the middle two bolt holes, the appropriate corrective action is replacement or reduction to Class 1 speeds under the provisions of §213.9(b) for a period not to exceed 30 days.

(d) If both joint bars are found to be broken entirely through between the middle two bolt holes, trains may be operated only under the visual supervision of a person designated under §213.7(a) and (b) at walking speed (not exceeding 4 MPH).

(e) In conventional jointed track, each rail must be bolted with at least two bolts at each rail end in Track Classes 2-9, and at least one bolt in each rail end in Track Class 1.

(f) In CWR, each rail must be bolted with at least two bolts at each rail end used to connect CWR strings or CWR to conventional track in accordance with Amtrak Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR.

(g) Each joint bar must be held in position by track bolts, or fasteners, tightened sufficiently to provide firm support for abutting rail ends and to allow longitudinal movement of rails in the joint to accommodate expansion and contraction due to temperature variations. In CWR, joints shall be tightened as much as possible, without regard for longitudinal expansion. When out-of-face, no slip, joint-to-rail contact exists by design, the requirements of this paragraph do not apply. Those locations are considered to be CWR and must meet all requirements for CWR in this Part.

(h) Where less than two bolts in a rail end are found to exist, the track must be protected by an appropriate speed restriction not to exceed 10 MPH (F) and 15 MPH (P).

(i) For one rail end unbolted and pull-aparts not in excess of 3", the speed will not exceed 10 MPH (F) and 15 MPH (P) and moves over this portion of track may only be allowed when under the constant observation of a person designated under §213.7. Where the inspector considers the track unsafe for the passage of trains, due to a combination of track conditions, the track will be put out-of-service until repairs are made.

(j) No rail or joint bar having a torch cut or burned bolt hole may be used in track. When new holes are necessary, they must be drilled. Punching, slotting or burning with a torch is prohibited except as provided in §213.122.

(k) No joint bar shall be reconfigured by torch cutting.

### §213.122 & §213.0122 Torch Cut Rail (FRA 213.122 & 213.352)

(a) Torch cut rail is prohibited except in an emergency temporary repair. If torch cutting is required, the subparagraphs 1 and 2 apply:

(1) On main tracks and tracks adjacent to main tracks, any torch cut rail must be kept under continuous observation. All movements over the torch cut rail must be visually supervised by a person qualified under §213.7(a) at walking speed (not exceeding 4 MPH).

(2) In other than main track territory, where the track speeds are 15 MPH or less, these rails will be renewed as soon as possible, but in no instance will they be left in service beyond seven days.

(b) Upon discovery of an existing torch cut rail, a 25 MPH (F) and 30 MPH (P) speed restriction shall be applied until the rail is removed.

(c) Existing torch cut rail discovered in Track Classes 1-9 are to be removed within 30 days of discovery. However, for Track Classes 1 and 2 not having occupied revenue passenger trains operating over the track, torch cut rail shall be removed within 12 months of discovery.

### §213.123 & §213.0123 Tie Plates (FRA 213.123)

(a) In Track Classes 3-9, no metal object that causes a concentrated load by solely supporting a rail shall be allowed between the base of the rail and the bearing surface of the tie plate. Examples include tie plate shoulders, spikes, etc.

(b) The requirements for effective tie plate distribution are described in the following table:

| | |
|---|---|
| Track Class 3 through 5 | At least 8 effective tie plates on any 10 consecutive ties |
| Track Class 6 through 9 | At least 9 effective tie plates on any 10 consecutive ties |
| Track Class 3 through 9 | No metal object causing a concentrated load between base of rail and tie plate |

### §213.125 & §213.0125 Rail Anchoring

(a) Longitudinal rail movement must be effectively controlled by use of rail anchors. No reduction in the number of anchors in track may be made without approval of the Deputy Chief Engineer-Track.

(b) A fully clipped wood tie and fully clipped and insulated concrete tie is equivalent to a box anchored wood tie.

(c) Anchoring patterns shall be in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR as required by 49 CFR §213.118.

(d) Rail anchoring of CWR must comply with these requirements. However, anchors previously applied to CWR in accordance with former standards need not be changed until the track is worked out-of-face.

### §213.127 & §213.0127 Rail Fastening Systems (FRA 213.127)

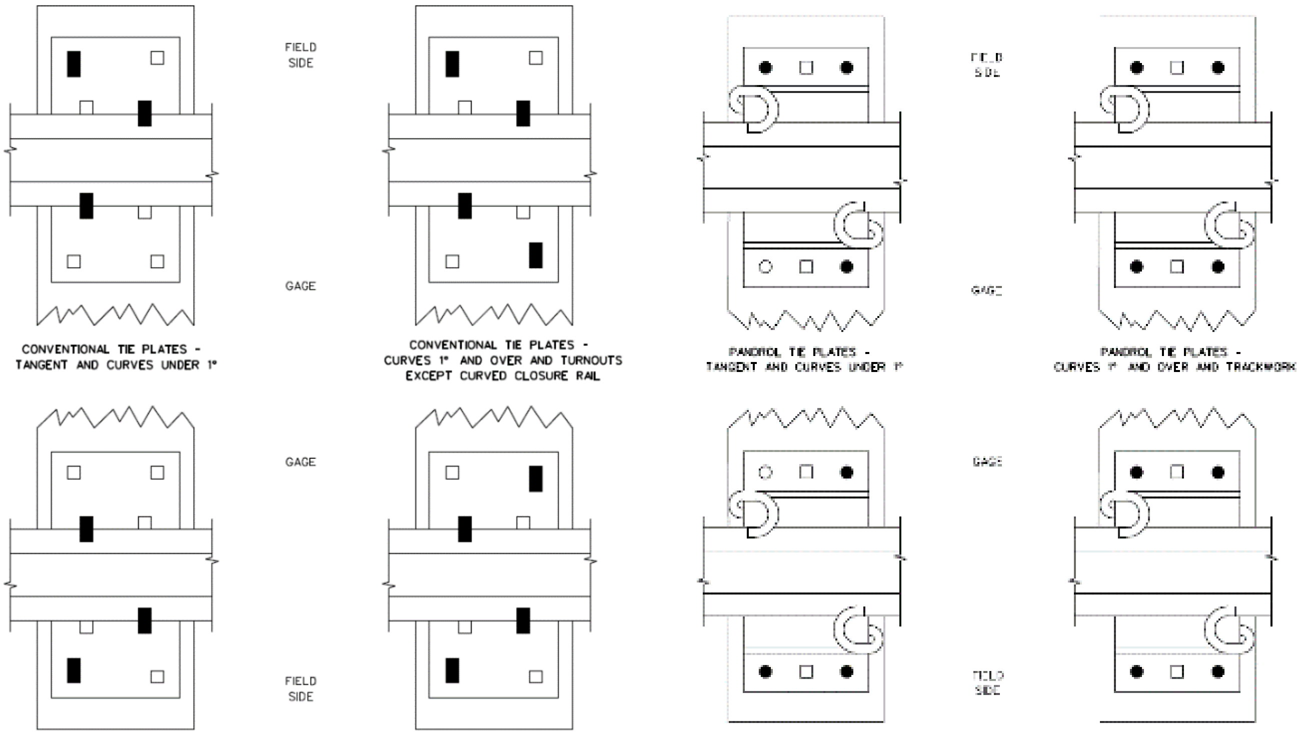
(a) Track shall be fastened by a system of components which effectively maintains gage within the limits prescribed in §213.53(b). Each component of each such system shall be evaluated to determine whether gage is effectively being maintained.

(b) Unless otherwise ordered by the Deputy Chief Engineer-Track, each rail shall be fastened to every tie given in accordance with the following table:

| **Track** | **Rail holding spikes [1]** | **Plate holding spikes or lag screws [1]** |
|---|---|---|
| *Conventional Tie Plates* | | |
| Tangent and curves under 1° | 2 | 1 |
| Curves 1° and over and trackwork except for curved closure rail | 2 | 2 |
| Curved closure rail of trackwork | 3 (1 field side; 2 gage side) | 1 (field side) |
| *Elastic Fastener Plates* | | |
| Tangent and curves under 1° | 2 Elastic Fasteners | 3 (2 field side; 1 gage side) |
| Curves 1° and over and trackwork | 2 Elastic Fasteners | 4 |

[1] Lock spikes (hairpins) are not to be used during maintenance or in new construction. Where lock spikes previously exist, they may remain until track is worked in a manner requiring them to be extracted. Inspectors must be aware that lock spikes tend to break inside the tie and look for indications of broken lock spikes such as plate push or loose spike in these areas.

(c) The application of fasteners shall be in accordance with §127.2(M) and Standard Track Plan AM 72051 as shown in the diagrams below:




(d) A tie that does not meet the requirements of paragraph (a) & (b) of this section is a defective tie for the purpose of §213.109.

(e) Each concrete crosstie must have four elastic fasteners, four insulators and two tie pads. If rail anchors are applied to concrete crossties, the combination of the crossties, fasteners, and rail anchors must provide effective longitudinal restraint.

(f) Each wood tie with an elastic fastener system must have four elastic fasteners and meet the requirements of §213.127.

(g) Where fastener replacement impedes insulated joints from performing as intended, modified fasteners may be used, or the fastener may be removed, provided that the crosstie supports the rail.

**§213.129 & §213.0129 Track Shims and Planks**

(a) If track does not meet the geometric limits and the working of ballast is not possible due to weather or natural conditions, track shims and/or planks may be installed to temporarily correct the track surface. See §129.0(M) and 131.0(M).

(b) When shims and planks must be installed, unless otherwise directed by design or approval from the Deputy Chief Engineering-Track, speeds may not exceed 50 MPH (F) and 90 MPH (P).

**§213.133 & §213.0133 Turnouts and Track Crossings; Generally (FRA 213.133 & 213.353)**

See Part II.

**§213.135 Switches (FRA 213.135)**

See Part II.

**§213.137 Frogs (FRA 213.137)**

See Part II.

**§213.139 Spring Rail Frogs (FRA 213.139)**

See Part II.

**§213.141 Self-Guarded Frogs (FRA 213.141)**

See Part II.

**§213.143 & §213.0143 Frog Guard Rails and Guard Faces; Gage (FRA 213.143 & 213.355)**

See Part II.

## Subpart E/G5 — Track Appliances and Track Related Devices

### §213.201 Scope (FRA 213.201)

See Part II.

### §213.205 & §213.0205 Derails (FRA 213.205 & 213.357)

See Part II.

## Subpart F/G6 — Inspection

### §213.231 Scope of Subpart (FRA 213.231)

This Subpart specifies the frequency and manner of inspecting track to detect deviations from the limits and requirements prescribed in this Part.

### §213.233 & §213.0233 Visual Track Inspections (FRA 213.233 & 213.365)

(a) All track must be inspected in accordance with the schedule prescribed in paragraph (c) of this section by a person designated under §213.7(b).

(b) Each inspection must be made on foot or by riding over the track in a vehicle at a speed that allows the person making the inspection to visually inspect the track structure for compliance with this Part. Mechanical, electrical, and other track inspection devices may be used to supplement visual inspection. If a high rail vehicle is used for visual inspection all movement shall be made in accordance with operating rules and as further limited by this paragraph. In no case shall the speed of the vehicle during inspection exceed 25 MPH nor 5 MPH when passing over track crossings, turnouts, and miter rails. Otherwise, the inspection vehicle speed shall be further limited at the sole discretion of the inspector(s), based on track conditions and inspection requirements. When inspecting track, the inspection will be subject to the following conditions:

  (1) One inspector in a vehicle may only inspect the track the vehicle occupies. With approval from the Deputy Chief Engineer of Track or designee, one inspector in a vehicle may inspect up to two tracks at one time provided that the inspector's visibility remains unobstructed by any cause and that the second track is not centered more than 30 feet from the track upon which the inspector is riding for a specific territory.

  (2) Two inspectors in one vehicle may inspect up to two tracks at a time provided that the inspectors' visibility remains unobstructed and that the track other than the one being occupied is centered within 39'. The tracks to be inspected are the track that the vehicle occupies plus one adjacent track on either side of the track occupied by the inspection vehicle. With approval from the Deputy Chief Engineer of Track or designee, two inspectors may inspect up to four tracks at a time provided the requirements for visibility above are met for a specific territory.

  (3) One inspector on foot may inspect up to two tracks at one time provided that the inspector's visibility remains unobstructed by any cause and that the second track is not centered more than 30 feet from the track upon which the inspector is walking.

  (4) Each main track must be traversed by the vehicle or inspected on foot at least once every two weeks, and each siding must be traversed by the vehicle or inspected on foot at least once every month.

  (5) Track inspection records must indicate which track(s) are traversed by the vehicle or inspected on foot as outlined in paragraph (b) of this section.

(c) Each track inspection must be made in accordance with the following schedule:

| Class of Track | Type of Track | Required Inspection Frequency |
|---|---|---|
| Excepted Track and Class 1-3 | Main tracks and sidings | Weekly with at least three calendar days between inspections; or before use, if the track is used less than once a week; or twice weekly with at least one calendar day between inspections, if the track carries passenger trains or carried more than 10 million gross tons of traffic during the preceding calendar year. |
| 1-3 | Other than main tracks and sidings | Monthly with at least 20 calendar days interval between inspections. |
| 4-5 | All track | Twice weekly with at least one calendar day interval between inspections. |
| 6-8 | All track | Twice weekly with at least two calendar day interval between inspections. |
| 9 | All track | Three times per week with at least one calendar day interval between inspections. |

(d) In addition to all tracks listed above, any track parallel to and centered within 30' of an Amtrak main track owned by others must be inspected monthly for compliance to its track class.

(e) In Track Classes 8 and 9, if no train traffic operates for a period of eight hours, a train shall be operated at speed not to exceed 100 MPH over the track before the resumption of operations at the maximum authorized speed.

(f) If the person making the inspection finds a deviation from the requirements of this Part, the inspector shall immediately initiate remedial action. Any subsequent movements to facilitate repairs on track that is out of service must be authorized by an MW 1000 qualified employee.

(g) In Track Classes 6-9, each switch, turnout and track crossing, and lift rail assemblies on moveable bridges must be inspected on foot at least weekly. The inspection must be in accordance with the procedures found in Part II.

Note: No part of this section will in any way be construed to limit the inspector's discretion as it involves inspection speed and sight distance.

**§213.234 Automated inspection of track constructed with concrete crossties (FRA 213.234)**

(a) General: Except for track described in paragraph (c) of this section, automated inspection technology shall be used as indicated in paragraph (b) below as a supplement to visual inspection for rail seat deterioration on concrete crossties as described in §213.109.

(b) Automated inspections shall be conducted at the following frequencies:

(1) If annual tonnage on Class 4 and 5 main track and Class 3 track with regularly scheduled passenger, exceeds 40 million gross tons (MGT) annually, at least twice each calendar year, with no less than 160 days between inspections.

(2) If annual tonnage on Class 4 and 5 main track and Class 3 track with regularly scheduled passenger, is equal to or less than 40 million gross tons (MGT) annually, at least once per calendar year.

(3) On Class 3, 4, and 5 main track with exclusively passenger service, either an automated inspection or walking inspection must be conducted once per calendar year.

(c) Non-application, sections of tangent track 600 feet or less constructed with concrete crossties, including, but not limited to, isolated track segments, experimental or test segments, highway-rail crossings, and way-side detectors, are excluded from the requirements of this section.

(d) Amtrak's methods of meeting this requirement utilize a rail profile measuring system to measure rail cant or the gage restraint measuring system on its automated inspection vehicles as outlined in Engineering Practices 2002 and 2007. All performance, training, and record keeping requirements shall be in accordance with 49 CFR §213.234.

**§213.235 & §213.0235 Inspection of Switches, Track Crossing, and Lift Rail Assemblies or Other Transition Devices on Moveable Bridges (FRA 213.235)**

See Part II for switches and track crossings and see Part III for lift rail assemblies or other transition devices on moveable bridges.

**§213.236 & §213.0236 Spring and Fall Track Inspections**

Spring & Fall Track Inspections shall be made in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

**§213.237 & §213.0237 Inspection of Rail (FRA 213.237 & 213.339)**

(a) In addition to the track inspections required by §213.233, a continuous search for internal defects must be made of all rail in Track Classes 3-9 in accordance with Engineering Practice 1809 Rail Testing using Detector Car, Walking Stick, and Hand Tester.

(b) A 0.08 service failure per year per mile of track in Classes 3-9 will govern the frequency of testing.

(c) All tracks Class 6-9 must be internally inspected no less than two times per year with not less 120 days between tests.

(d) Inspection equipment must be capable of detecting defects between joint bars, in the area enclosed by joint bars.

(e) Each defective rail must be marked with a highly visible marking on both sides of the web and base.

(f) If the person assigned to operate the rail defect detection equipment being used determines that, due to rail surface conditions, a valid search for internal defects could not be made over a particular length of track, the test on that particular length of track cannot be considered as a search for internal defects under 213.237(a).

(g) If a valid search for internal defects cannot be conducted for reasons described in paragraph (f) of this section, the Deputy Chief Engineer-Track shall, before the expiration of time or tonnage limits:

  (1) Conduct a valid search for internal defects.

  (2) Reduce operating speed to a maximum of 25 MPH until such time as a valid search for internal defects can be made.

  (3) Remove the rail from service.

### §213.0238 Initial Inspection of New Rail and Welds (FRA 213.341)

In track classes 6 through 9, newly manufactured rail and initial inspection of new welds made in either new or used rail shall be inspected for internal defects by one of the following methods:

(a) In-service inspection: A scheduled periodic inspection of rail and welds that have been placed in service, if conducted in accordance with the provisions of §213.237 and not later than 90 days after installation, shall constitute compliance with paragraphs (b) and (c) of this section.

(b) Mill inspection: A continuous inspection at the rail manufacturer's mill shall constitute compliance with the requirement for initial inspection of new rail, provided that the inspection equipment meets the applicable requirements specified in §213.237. The Deputy Chief Engineer-Track shall obtain a copy of the manufacturer's report of inspection and retain it as a record until the rail receives its first scheduled inspection under §213.237.

(c) Welding plant inspection: A continuous inspection at a welding plant, if conducted in accordance with the provisions of paragraph (b) of this section and accompanied by a plant operator's report of inspection which is retained as a record by the Deputy Chief Engineer-Track, shall constitute compliance with the requirements for initial inspection of new rail and plant welds, or of new plant welds made in used rail.

(d) Inspection of field welds: Initial inspection of new field welds, either those joining the ends of CWR strings or those made for isolated repairs, shall be conducted not less than one day and not more than 30 days after the welds have been made. The initial inspection may be conducted by means of portable test equipment. The Deputy Chief Engineer-Track shall retain a record of such inspections until the welds receive their first scheduled inspection under §213.237.

(e) Each defective rail found during inspections conducted under paragraph (a) or (d) of this section must be marked with highly visible markings on both sides of the web and base and the remedial action as appropriate under §213.113 will apply.

### §213.238 Qualified Operator (FRA 213.238)

Refer to 49 CFR 213.238.

### §213.239 & §213.0239 Special Inspections (FRA 213.239 & 213.367)

In the event of fire, flood, temperature extremes, severe storm, or other occurrence that might damage the track structure, a special inspection and report must be made of the track involved as soon as possible after the occurrence and, if possible, before the operation of any train over that track.

### §213.240 Continuous Rail Testing (FRA 213.240)

Refer to 49 CFR 213.240.

### §213.241 & §213.0241 Inspection Records (FRA 213.241 & 213.369)

(a) Each Division Engineer to which this Part applies shall keep a record of each inspection required to be performed.

(b) Each record of an inspection shall be prepared on the day the inspection is made and signed or otherwise certified by the person making the inspection. Records must specify the track inspected, date of inspection, location and nature of any deviation from the requirements of this Part, and the remedial action taken by the person making the inspection. All records must be maintained in accordance with Amtrak's Record Retention Policy.

(c) Rail inspection records must specify the date of inspection, the location and nature of any internal defects found, the remedial action taken and the date thereof, and the location of any intervals of track not tested per §213.237(d). The rail inspection record shall be retained in accordance with Amtrak's Record Retention Policy.

(d) Each Division Engineer required to keep inspection records under this section shall make those records available for inspection and copying by the FRA.

**§213.242 & §213.0242 Responsibilities for Inspection and Reporting**

(a) Track Supervisors or a Division Officer will review, sign and date all Daily Track Inspection Reports for their territory.

(b) Track Supervisors or a Division Officer will review, sign and date a copy of Monthly Switch Inspection Forms for their territory.

(c) General Foremen, Assistant Track Supervisors, Track Supervisors, or a Division Officer will spend at least one day per week with one of their Track Inspection Foremen inspecting their assigned territory in accordance with their normal inspection practices. This is to be done in rotation, on a weekly/monthly basis, until the entire territory is inspected.

(d) Division Officer (Engineer Track or above) will inspect their main line tracks twice each year (Spring and Fall), following normal inspection practices, with the responsible Track Inspection Foreman.

(e) Track Inspection Audit Reports will be used in accordance with paragraphs (c) and (d) of this Subpart.

**§213.243 Track Inspection Reports**

(a) The Amtrak Engineering Department requires that a number of inspection reports be filled out for scheduled and special inspections.

(b) Electronic record keeping for track inspections is the preferred method; the Form Numbers listed in the table below can be used in lieu of electronic forms if needed.

| Report | Form Number (NRPC) | Reference | Copies To |
|---|---|---|---|
| Daily Track Inspection | 1580 "Daily Track Inspection Report" | MW 1000, Part I, §213.233, and 213.7 | Track Inspector, Track Supervisor, Division Engineer |
| Fall and Spring Track Inspection | 2781 "Track Inspection Audit Report" 2880 "Special Track Occurrence Report" | MW 1000, Part I, §213.234 | Track Inspector, Track Supervisor, Division Engineer, Deputy Chief Engineer-Track |
| Monthly Switch Inspection | 2181 "Joint Switch & Frog Inspection and Test Report" | MW 1000, Part II | Track Inspector, Track and C&S Supervisors, Division Engineer |
| Weekly Switch Inspection | 1580 "Daily Track Inspection Report" | MW 1000, Part II | Track Inspector, Track Supervisor and Division Engineer |
| Annual Switch and Frog Inspection | 2106 "Report of Inspection of Frogs and Switches" | MW 1000, Part II | Track Supervisor, Division Engineer, Deputy Chief Engineer- Track |
| Twice Weekly Miter Rail and Expansion Joint Inspection | 1580 "Daily Track Inspection Report" | MW 1000 Part III, §213.231 (MR) | Track Inspector, Track Supervisor, Division Engineer |
| Monthly/Quarterly Miter Rail and Expansion Joint Inspection | Miter Rail Inspection Form | MW 1000 Part III, §213.231 (MR) | Track Inspector, Track Supervisor, Division Engineer |
| Special Inspection | 2880 "Special Track Occurrence Report" | MW 1000, Part I, §213.239, Amtrak CWR Policy | Track Inspector, Track Supervisor, Division Engineer, Deputy Chief Engineer-Track |
| Rail Joint Inspection | 2880 “Special Track Occurrence Report” | Engineering Practice No. 1816, MW 1000, Part 1, §213.121 | Track Supervisor, Division Engineer, Deputy Chief Engineer-Track |
| Broken Rail Report (Service) | 2806 "Report of Rail Failure In Main Track" | Engineering Practice No. 204 | Track Foreman, Track Supervisor, Division Engineer and Deputy Chief Engineer-Track. |
| Record of Disturbance of Main CWR Track | "Report A" | Amtrak CWR Policy | Track Supervisor |
| Report of Track Movement Due to Surfacing and Lining of Curves | "Report B" | Amtrak CWR Policy | Track Supervisor, Division Engineer |
| Summary Report of Track Disturbance | "Report C" | Amtrak CWR Policy | Track Supervisor, Deputy Chief Engineer-Track |
| Thermal Log for Rail Expansion | "Report D" | Amtrak CWR Policy | Track Supervisor, Division Engineer, Foreman |

### §213.250 & §213.0250 Tool Requirements

(a) The Track Foreman or person responsible for performing the track/switch inspection shall plan ahead and coordinate with the Track Supervisor to ensure that inspection tools are available when the inspection is made.

(b) The Track Foreman or person responsible for performing the inspection shall notify the Track Supervisor when tools become in disrepair so that a tool can be fixed or replaced.

(c) Specified numerical limits given in all Parts are to be confirmed during the track/switch inspection with the appropriate tool. Values are not to be estimated or approximated. Only measured values are to be recorded.

(d) The Track Foreman or person responsible for performing inspections are encouraged to make periodic recommendations for improvements in existing tools or gauges and changes in tools that are needed to make the required inspection measurements.

### §213.251 Inspection Tools

(a) In addition to what is listed below, reference Engineering Practice EP2318 Track Inspection – Inspection Tool Requirements.

(b) Marking crayon (keel) may be used to mark stations, tie lengths, dimensional data, and other information that will be made part of the inspection.

(c) A measuring tape or folding ruler may be used to measure track components and ties in the turnouts. The tape or ruler shall be non-conducting. The tape or folding rule can also be used to measure switch point throw, frog guard face and guard check, stations for alignment measurements, rail flow, tie spacings, offsets, and other key dimensional data.

(d) A standard combination track gauge with level board shall be used so that gage, flangeway, crosslevel and superelevation measurements can be made.

(e) A machined straightedge (minimum 18" in length) shall be used to measure batter and chipping of rail ends, wear, soft spots, engine burns on frogs and rail heads, and rail end mismatch.

(f) A taper gauge shall be used in conjunction with the straightedge to measure the depth of engine burns, soft spots, batter, and other anomalies in the rail head. In addition, the taper gauge shall be used to measure switch point/stock rail gap, and the gap at the moveable point frog.

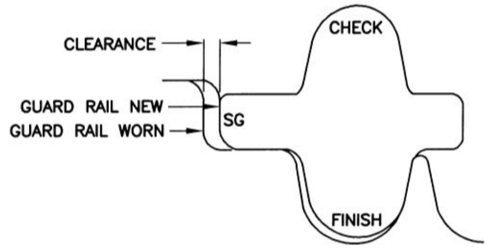
(g) String line equipment capable of measuring 31', 62' and 124' chords shall be used to check alignment & surface spots. An example of the equipment used is found in Standard Track Plan AM 77330.

(h) The following gages may be used to check critical dimensions in and around frogs:

  (1) Flangeway gage: the gage is designed to measure the flangeway in worn frogs so that grinding and welding repairs can be programmed. The gage to be used by the track inspector shall conform to American Railway Engineering and Maintenance Association (AREMA) Plan No. 790-94.

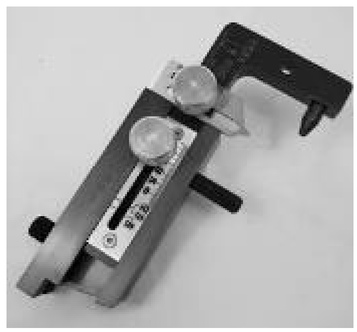
  (2) Guard wear gage: the gage is designed to measure the wear on the guarding faces on a self-guarded frog. The gage to be used by the track inspector shall conform to AREMA Plan No. 790-94.

(i) The following check gage is used to test the flangeways in worn frogs and crossings for grinding or for welding repairs when necessary. It is designed for normal 1-7/8" flangeways and proper allowance should be made when used with wider flangeways.




(j) The track inspector shall ensure that the level board is checked and maintained to measure correct crosslevel readings.

(k) Rail wear gauge shall be used to measure gage face and vertical (tread) wear on rails.



# SUBPARTS A-D

# LIMITS AND SPECIFICATIONS FOR TRACK MAINTENANCE

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# LIMITS AND SPECIFICATIONS FOR TRACK MAINTENANCE
# SUBPARTS A-D
### Track Classes 1-9

## Table of Contents

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## Subpart A(M) – General

### §1.0(M) Scope of Subpart

(a) Maintenance is replacing a component of the track structure such as laying new or fit rail or installing ties. Maintenance limits are to be used as a triggering mechanism that prompt maintenance or reconstruction. It is Amtrak's policy to have a track structure that stays between construction and maintenance limits. As the track structure breaks down, maintenance should be programmed before the track reaches the maintenance limits. Maintenance must be executed whenever the maintenance limits are exceeded and completed prior to reaching the safety limits. Whenever possible, track should be repaired or reconstructed to construction limits.

(b) This subpart provides standards that will be used in conjunction with Standard Track Plans and Engineering Practices for the maintenance of track. It is for the guidance to Engineering Department forces, contractors and others repairing track. Any portions of this Part may be included in a contract and carry the same force as specifications, when so used.

(c) This subpart contains "maintenance limits" that are to be used when maintaining track and are not to be confused with the "safety limits" or the "construction limits".

(d) Except when designated as part of a specification in a contract, it is not the intent of this Part to establish arbitrary procedures or values, but to serve as a guide that must be considered in the light of experience and the requirements of the service.

### §7.0(M) Quality Control

(a) The person in charge of performing the maintenance activity or repair shall be responsible for the overall quality of the work performed.

(b) All maintenance work shall be performed in accordance with appropriate Engineering Practices, MW 1000, and Standard Track Plans.

(c) The Track Supervisor and Assistant Division Engineer shall periodically review the work performed for quality, consistency, and adherence to Engineering Practices.

(d) Trackwork repairs that are deficient:

   (1) May be cause for remedial action

   (2) Shall be brought to the attention of the local Track Supervisor

(e) The Track Supervisor shall see that any additional work necessary is performed to bring the repair into compliance with Amtrak standards and procedures.

(f) The Track Supervisor shall be responsible to re-inspect substandard or deficient work to ensure that the corrective work is in compliance with Amtrak practice, procedures, and standards.

(g) Division Officers, along with the Track Supervisors and Foreman, are encouraged to make recommendations to the Division Engineer or Deputy Chief Engineer-Track as to required modifications to methods, procedures, and practices to improve the overall quality of work.

## Subpart B(M) - Roadbed and Right-of-Way

### §33.0(M) Drainage

(a) Drainage facilities shall be inspected on an annual basis for obstructions or damaged infrastructure. Water falling upon the roadbed should be quickly and efficiently drained.

(b) Each drainage or other water-carrying facility under or immediately adjacent to the roadbed (including but not limited to drainage ditches, culverts, underdrains, and catch basins) must be maintained and kept free of obstruction and debris to accommodate expected water flow for the area.

(c) Distribution of track or construction materials, the casting of fouled ballast, installation of duct banks, installation of structures, or trenching should be handled in such a manner that it does not interfere with any drainage structure or obstruct any existing flow path.

(d) Adequate cross drains should be maintained, particularly where bridges, road crossings, and sags interfere with longitudinal drainage.

(e) Water seeping or flowing toward the track should be conducted across the roadbed or be intercepted and diverted before it reaches the roadbed.

(f) Maintenance of drainage systems must satisfy the requirements of §213.33.

### §35.0(M) Cross Section

Roadbeds, embankments, and excavations should be maintained in accordance with Standard Track Plan AM 70003. Deviation from approved cross sections should not be made without authorization by the Deputy Chief Engineer-Track.

### §37.0(M) Vegetation

(a) Growth of vegetation should be encouraged on slopes of embankments, cuts, and deep ditches to prevent erosion.

(b) Vegetation growth must be controlled in accordance with the requirements of §213.37.

### §39.0(M) Signs and Posts

Track signs and posts must be placed and maintained in accordance with Standard Track Plans and special instructions. They should not be installed so as to interfere with signals or safety appliances.

### §41.0(M) Highway Grade Crossings

### §41.1(M) Authority for Protection

In addition to rules prescribed in "Operating Rules and Instructions," public and private grade crossings shall be protected according to degree of hazard, state statutes, township and municipal ordinances and public service commission regulations with the sign or device approved by the governing body.

### §41.2(M) Forms of Protection

(a) Whistle signs shall be installed in accordance with Standard Track Plan AM 78410.

(b) Highway grade crossing signs shall conform to Standard Track Plan AM 78302. Automatic protection, including flashing light signals and crossing gates, shall conform to applicable C&S Specifications and Plans:

   (1) Where track circuits for crossing protection are applied to sidings or yard tracks, the limits of the circuits on such tracks shall be indicated by a "CC" sign or by a yellow stripe approximately 10" wide painted on the inside and outside of the head, web and base of both rails, which must be kept clear of snow, ice, dirt and weeds, and must be repainted as often as necessary.

### §41.3(M) Maintenance

(a) All signs and other forms of protection for at-grade crossings must be immediately repaired or replaced when damaged.

(b) Crossings should be kept clean and attention given to the following:

   (1) Drainage, sloping the surface if necessary, and constructing underground drains.
   (2) Surface water flowing along highway toward the railroad should be diverted before it reaches the tracks.
   (3) The width of the crossing shall be sufficient to extend at least 3' beyond each edge of the traveled width of the highway. The crossing surface should be supported by shoulders placed in the spaces between tracks.
   (4) Highway approaches to track areas should be on smooth grades without abrupt breaks, so that low road clearance vehicles carrying large shipments, such as heavy machinery, may pass over the tracks without touching the rails or surface of crossings with their underframes.
   (5) Flangeways shall be 2-1/2" wide and not less than 2" deep. They must be kept clean at all times and free of ice and snow.
   (6) The view of both directions from vehicles approaching the track shall be kept as clear as practicable.
   (7) When installing or making general repairs to crossings, track alignment should be established by transit line, string line calculations, or mechanical lining devices.
   (8) Use of gage rods in crossings is prohibited.
   (9) Rail anchors shall be used provided they do not interfere with the installation of the crossing materials.
   (10) The ends of the crossing shall be protected against dragging equipment with deflector assemblies.
   (11) Rail joints shall not be located closer than 120' from the end of a crossing.

### §41.4(M) Conduct of Work

Work on highway crossings, public streets and roads shall be done with the least inconvenience possible to highway travelers. Care must be taken to protect the work in compliance with the safety requirements and the law. Where it is necessary to construct temporary footwalks or driveways, they must be kept in a safe condition.

## §43.0(M) Wire Lines

### §43.1(M) Communication and Signal Lines

(a) When repairing and working on or about wire lines, all applicable rules must be strictly observed.

(b) All Maintenance of Way employees must observe the general condition of poles and wires along and across the tracks and right-of-way, and report any conditions needing correction, such as: broken wires, uprooted trees or broken branches in the wires, or broken or leaning poles, to responsible C&S employees and the Supervisor-Track.

(c) Trees near wire lines should be kept trimmed or removed when decayed to such an extent as to be unsafe, to prevent interference with wires, or with the view of signals.

## §44.0(M) Fencing

### §44.1(M) Right-of-Way Fencing

(a) Fencing shall be maintained for security purposes.

(b) Gates shall be maintained and locked at all times.

(c) Maintenance of Way personnel shall observe the condition of the fence and report damage.

### §44.2(M) Intertrack Fencing

(a) Intertrack fencing shall be maintained such that it will not interfere with the safe passage of trains.

(b) Intertrack fencing shall be maintained in accordance with Standard Track Plan AM 70050.

## Subpart C(M) - Track Geometry

### §53.0(M) Gage

### §53.1(M) Standard for Gage

(a) The standard gage for track is 56-1/2" and is measured 5/8" below the top of rail. Gage on curves over 13° and for turnouts less than No. 8 will be specified by the Deputy Chief Engineer-Track.

(b) Where existing gage conforms to standards previously in effect and is in compliance with §213.53, change need not be made until rail is renewed or out-of-face gaging is performed.

(c) When gaging is required, care should be taken to not adversely affect the alignment of the track. Changes in prescribed gage should be made in uniform increments as given in §53.2(M).

(d) Gage shall be changed by adjustment of the rail opposite the line rail. (Preferred Method)

(e) Gage may be adjusted on the line rail only if the adjustment will improve line and ride quality (e.g., joint elbowed out on the line rail).

### §53.2(M) Maintenance of Gage

(a) Gage shall be measured with a standard track gauge or other authorized devices. These devices must be checked prior to daily use for accuracy.

(b) Maintenance shall be performed when gage reaches the following limits:

| Gage Maintenance Limits | | | |
|---|---|---|---|
| **Class of Track** | Minimum (inches) | Maximum (inches) | Maximum Rate of Change within 31' (inches) |
| **1** | 56-1/4 | 57-1/2 | 1 |
| **2** | 56-1/4 | 57-1/2 | 1 |
| **3** | 56-1/4 | 57-1/2 | 3/4 |
| **4-5** | 56-1/4 | 57-1/4 | 1/2 |
| **6-8** | 56-1/4 | 57 | 3/8 |
| **9** | 56-3/8 | 57 | 3/8 |

## §55.0(M) Alignment

### §55.1(M) Alignment Maintenance Limits

(a) Single deviations – Maintenance shall be performed when alignment values reach the following limits:

| Single Deviation Alignment Maintenance Limits | | | | |
|---|---|---|---|---|
| Class of Track | | Chord Length | | |
| | | 31' | 62' | 124' |
| 1 | Tangent | - | 3-3/4" | - |
| | Curve $E_u \leq 5"$ | 2-3/4" | 3-3/4" | - |
| | Curve $E_u > 5"$ | 1" | 1" | - |
| 2 | Tangent | - | 2-1/4" | - |
| | Curve $E_u \leq 5"$ | 1-1/2" | 2-1/4" | - |
| | Curve $E_u > 5"$ | 3/4" | 1" | - |
| 3 | Tangent | - | 1-1/4" | - |
| | Curve $E_u \leq 5"$ | 7/8" | 1-1/4" | - |
| | Curve $E_u > 5"$ | 5/8" | 1" | - |
| 4 | Tangent | - | 1" | - |
| | Curve $E_u \leq 5"$ | 3/4" | 1" | - |
| | Curve $E_u > 5"$ | 5/8" | 3/4" | - |
| 5 | Tangent | - | 1/2" | - |
| | Curve $E_u \leq 5"$ | 3/8" | 1/2" | - |
| | Curve $E_u > 5"$ | 3/8" | 1/2" | - |
| 6 | Tangent | 3/8" | 1/2" | 1" |
| | Curve $E_u \leq 5"$ | 3/8" | 1/2" | 1" |
| | Curve $E_u > 5"$ | 3/8" | 1/2" | 1" |
| 7 | Tangent | 3/8" | 3/8" | 7/8" |
| | Curve $E_u \leq 5"$ | 3/8" | 3/8" | 7/8" |
| | Curve $E_u > 5"$ | 3/8" | 3/8" | 7/8" |
| 8-9 | Tangent | 3/8" | 3/8" | 1/2" |
| | Curve $E_u \leq 5"$ | 3/8" | 3/8" | 1/2" |
| | Curve $E_u > 5"$ | 3/8" | 3/8" | 1/2" |

(b) Multiple deviations – For Track Classes 6-9, maintenance shall be performed when alignment values deviate from uniformity more than the amount prescribed in the following table for three or more non-overlapping deviations occurring with a distance equal to five times the specified chord length.

| Multiple Deviations Alignment Maintenance Limits | | | |
|---|---|---|---|
| Class of Track | Chord Length | | |
| | 31' | 62' | 124' |
| 6 | 1/4" | 3/8" | 3/4" |
| 7 | 1/4" | 1/4" | 5/8" |
| 8 & 9 | 1/4" | 1/4" | 3/8" |

(1) Uniformity at any point along the track is established by averaging the measured mid-chord offset values for nine consecutive points centered around that point spaced according to the following table:

| Chord Length | Spacing |
|---|---|
| 31’ | 7’ 9" |
| 62’ | 15' 6" |
| 124’ | 31' 0" |

(2) The ends of the line or chord must be at points on the gage side of the line rail, 5/8" below the top of the rail head. Use line rail in accordance with §55.1(M).

(3) In track classes 1 through 5, both 31’ and 62’ chord lengths shall be used. In track classes 6 and above 31’, 62’ and 124’ chord lengths shall be used.

(c) The alignment of track and superelevation on curves in overhead electrified territory must not be changed until proper notice has been given to the Electric Traction Department.

(d) Curve realignment changes must be made in accordance with Amtrak’s Procedures for the installation, adjustment, maintenance, and inspection of CWR.

(e) Alignments must be maintained within the prescribed limits given above and must meet minimum roadway clearances prescribed in Standard Track Plan AM 70050.

**§55.2(M) String Lining Curves**

(a) String lining of curves is based on the following principles:

(1) The mid-ordinates of a curve are indicative of its degree of curvature.

(2) The mid-ordinates of a circular curve are equal for chords of uniform length.

(3) For practical purposes, the mid-ordinate varies directly with the degree of curvature.

(4) Where track is thrown in or out at any single station on the curve, the mid-ordinate of the curve at the station is affected by the amount of the throw and the mid-ordinates at the adjacent stations are automatically affected by half the amount, but in the opposite direction.

(b) String lining of curves is a method for determining the most advantageous alignment that can be obtained with reasonable amounts of throw.

(c) Any of the established mathematical methods, such as "Bartlett Method" or "Bracket Method," may be used to calculate the throws of curves. All calculations should be checked to ascertain that the calculated throws will produce the required changes in mid-ordinates. An example of string line calculations is shown on Standard Track Plan AM 77330.

(d) Track shall be stationed for string lining on the gage side of the outer (high side) rail of the curve, with stationing marked on the web or base of the rail.

(1) Stationing shall begin at a point on the tangent far enough ahead to permit the measurement of any reverse curvature or "dog-leg," and continue throughout the curve to a point on the tangent far enough to permit measurement of any reverse curvature on the leaving end.

(2) 31' stations (62' chords) should be used for most curves found in main tracks, in which case a mid- ordinate of 1" will indicate 1° of curvature. It may be desirable to use 44' stations for curves under $0^{o}$-30', or to use 22' stations for sharp curves.

(3) The practical relationship between station and chord length, mid-ordinate and degree of curvature for various stationing is shown in the following table:

| Chord Length | Station Length | Mid-ordinate | Degree of Curvature |
|---|---|---|---|
| **31'** | 15'-6" | 1/4" | 1-00' |
| **44'** | 22' | 1/2" | 1-00' |
| **62'** | 31' | 1" | 1-00' |
| **88'** | 44' | 2" | 1-00' |
| **124'** | 62' | 4" | 1-00' |

(e) Mid-ordinates should be measured to the gage side of the string in 1/16" increments using an approved string line kit.

(1) Mid-ordinate measurements should be taken with the string line pulled taut, not affected by the wind, and with the string line holders and the scale held horizontal and perpendicular to the gage.

(2) If a conventional rule is used to measure the mid- ordinate, the actual scale reading should be recorded and a correction made to compensate for the 1" offset of the string line from the rail when calculations are made, to avoid field errors. Direct compensated readings of mid-ordinates may be recorded using a scale similar to that shown on Standard Track Plan AM 77330.

(3) The String Line Data Form (See Standard Track Plan No. AM 77330) should be used to record field measurements and for making mathematical calculations. The latest calculations or records of field measurements should be retained by the Supervisor-Track for record purposes.

(f) Track center distances should be measured and recorded at every station in multi-track territory. Stationing with shorter lengths shall be used where close track centers are encountered. The distance from centerline of track to any obstruction that might interfere with the lining of the curve should be measured and recorded so that limiting throws for these tight spots may be determined.

**§55.3(M) Referencing Track for Maintenance Lining**

(a) Determining Line Rails:

i. Outer rails of curves and field side rails on tangents should be selected as the line rails.

ii. On single tangent track, either rail may be used as the line rail, however, the north or east rail is the preferred line rail. The same line rail shall be used for the full length of that tangential segment of track.

iii. For switches or turnouts the rail opposite the point of frog should be used as the line rail.

(b) Existing Track Center Measurements

i. Curves shall be measured horizontally from the gage side of the line rail of the reference track to the gage side of the line rail of track to be worked. When necessary, plumb bobs shall be used as a measurement aid.

ii. Tangents on either side of curves shall be measured using the same reference rail as in the curve.

iii. In multiple-track territory, an adjacent track shall be used to measure and record track centers for referencing. The track used for referencing shall not be disturbed until the lining operation on the track being worked is completed.

iv. For switches or turnouts track centers should be taken at point of frog.

(c) After calculating the required throws as per §55.2(M), the resulting track center for each station is calculated by adding the throw required for that station to the existing track center distance.

(d) Track centers should be measured immediately after each pass and compared to the calculated track center. Track centers measurements should be taken, at a maximum, every 400 feet.

(e) Minimum track center distances must be maintained during each pass per §61.0(M).

(f) Lining a curve in CWR territory must be done in accordance with Amtrak's Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR.

## §57.0(M) Curvature, Superelevation and Speed

### §57.1(M) General

(a) Superelevation, or Cant is the vertical distance of the outer rail of a curve above the inner rail. It is provided to overcome or partially overcome the centrifugal effects of curvature and speed.

(b) Equilibrium superelevation is that which exactly overcomes the effect of negotiating a curve at a given speed for any given degree of curvature, placing the resultant centrifugal force and weight of equipment in a direction perpendicular to the plane of the track.

(c) Underbalance (cant deficiency) is the amount that a superelevation is less than equilibrium superelevation for any given combination of speed and curvature.

(d) Overbalance is the amount that a superelevation exceeds equilibrium superelevation and is produced by the operation of a train around a curve at less than equilibrium speed or stopping on the curve.

(e) Authorized speed is that specified in the current Employee's Timetable.

### §57.2(M) Superelevation

The Deputy Chief Engineer-Track shall establish the amount of superelevation, underbalance, and speed to be placed and maintained on each curve. Maximum maintenance superelevation shall not exceed 6". See Appendix B, Underbalance Table Maximum Allowable Operating Speed on Curves.

### §57.3(M) Curve Information

(a) The degree of curve (degrees-minutes-seconds), radius (feet), required superelevation (inches) and the length (feet) for each segment of a curve shall be designated at the control points of each curve.

(b) Superelevation tags used in accordance with previous standards need not be changed until such time as the designated superelevation or spiral lengths for that curve are changed.

## §61.0(M) Clearances and Track Centers

### §61.1(M) Track Centers

(a) In maintaining alignment, the existing track centers, including equivalent centers on curves, must not be reduced below the minimum established for the territory.

(b) A permanent record of track centers between main tracks, and between main and adjacent sidetracks, should be maintained by Division Engineers.

(c) Any changes in track centers must be immediately reported to the Division Engineer's office.

(d) The minimum acceptable existing tangent track center for any location is 12'. In addition, on curves, the 12' minimum track center must be increased as follows:

  (1) Where the amount of superelevation is the same on adjacent tracks or the superelevation of the inner track is greater than the superelevation of the outer track, increase the tangent track center distance by 1" for each 0°-30' of curvature.

  (2) Where the superelevation of the outer track is greater than the superelevation of the inner track, the tangent track center distance should be increased 1" for each 0°-30' of curvature, plus 3-1/2" for each 1" of difference in superelevation of the two tracks considered.

### §61.2(M) Intertrack Clearance Limiting Objects

(a) For the following signals placed between the tracks, track center distances shall not be less than 25':

  (1) One arm position light signals, where the center of the background is less than 18' above top of rail.

  (2) Two arm position light signals, where a bottom arm other than a marker or vertical aspect is used, and the center of the bottom arm aspect is less than 18' above top of rail.

  (3) Search light or color light signals, where the overall width of the signal is in excess of 24" at any point less than 18' above top of rail.

(b) For signals, other than dwarf and those described in paragraph (a), the track center distance shall not be less than 19'.

(c) For signal bridge supports, pedestal signals or switch stands with intermediate or high staff, the track center distance shall not be less than 19'.

### §61.3(M) Other Clearance Limiting Objects

For clearance limiting objects other than those described in §61.0(M), see Standard Track Plan AM 70050.

## §62.0(M) Grades

### §62.1(M) Limitations

No grades shall be introduced exceeding a rate of 2-1/2% unless authority has been obtained from the Deputy Chief Engineer-Track.

## §63.0(M) Track Surface

### §63.1(M) General

(a) The profile of track being surfaced should not be raised above established grades, except under instructions from the Deputy Chief Engineer-Track, who will consider the required elevations and clearances in tunnels, under catenary systems and overhead structures, and at interlocking plants, undergrade bridges, platforms and highway grade crossings.

(b) Any encroachment upon the published minimum overhead or side clearances from a track will not be permitted.

### §63.2(M) Maintenance

(a) The following criteria will serve as a practical guide for maintaining smooth riding conditions in existing tracks.

(b) Maintenance shall be performed prior to the surface reaching the following limits:

| SINGLE POINT – Deviation from uniform profile on either rail at mid-chord: | | | | |
|---|---|---|---|---|
| Class of Track | | Chord Length | | |
| | | 31’ | 62’ | 124’ |
| 1 | Tangent/Curve Eu ≤ 5” | - | *2-1/4”* | - |
| | Curve Eu > 5” | - | *1-5/8”* | - |
| 2 | Tangent/ Curve Eu ≤ 5” | - | *2”* | - |
| | Curve Eu > 5” | - | *1-5/8”* | - |
| 3 | Tangent/ Curve Eu ≤ 5” | - | *1-5/8”* | - |
| | Curve Eu > 5” | *3/4”* | *1-3/8”* | - |
| 4 | Tangent/ Curve Eu ≤ 5” | - | *1-1/2”* | - |
| | Curve Eu > 5” | *3/4”* | *1”* | - |
| 5 | Tangent/ Curve Eu ≤ 5” | - | *1”* | - |
| | Curve Eu > 5” | *3/4”* | *3/4"* | - |
| 6 | Tangent/ Curve Eu ≤ 5” | *3/4”* | *3/4"* | *1-1/4”* |
| | Curve Eu > 5” | *3/4”* | *3/4"* | *1-1/8”* |
| 7 | Tangent/ Curve Eu ≤ 5” | *3/4”* | *3/4"* | *1”* |
| | Curve Eu > 5” | *3/4"* | *3/4"* | *1”* |
| 8 | Tangent/ Curve Eu ≤ 5” | *1/2”* | *3/4"* | *7/8”* |
| | Curve Eu > 5” | *1/2"* | *3/4"* | *7/8”* |
| 9 | Tangent/ Curve Eu ≤ 5” | *3/8”* | *1/2"* | *7/8”* |
| | Curve Eu > 5” | *3/8”* | *1/2"* | *7/8”* |

| MULTIPLE DEVIATION – Three or more non-overlapping deviations within five times the chord length, each deviation from uniformity at mid-chord offset may not be more than: | | | |
|---|---|---|---|
| **Track Class** | **Chord Length** | | |
| | **31’** | **62’** | **124’** |
| **4** | *-* | *1”* | *-* |
| **5** | *-* | *3/4"* | *-* |
| **6** | *1/2"* | *1/2"* | *7/8”* |
| **7** | *1/2”* | *1/2"* | *3/4"* |
| **8** | *3/8”* | *1/2"* | *5/8”* |
| **9** | *1/4"* | *3/8”* | *5/8”* |

| RUNOFF – in any 31’ of the rail at the end of a raise may not be more than: | |
|---|---|
| **Class of Track** | |
| **1** | *2-5/8”* |
| **2** | *2-1/4”* |
| **3** | *1-1/2”* |
| **4** | *1-1/8”* |
| **5-7** | *3/4”* |
| **8-9** | *3/8”* |

| Reverse Elevation in Curves | |
|---|---|
| **Class of Track** | |
| **1** | *2-1/4”* |
| **2** | *1-1/2”* |
| **3** | *1-3/8”* |
| **4** | *1-1/4”* |
| **5** | *1”* |
| **6-9** | *1/2”* |

| CROSSLEVEL & WARP | | | |
|---|---|---|---|
| **Class of Track** | **CROSSLEVEL in Tangent** | **WARP – Difference in Crosslevel between any two points (Tangent, Spiral or Curve) within:** | |
| | | **10’ (short warp)** | **62’ [1]** |
| **1** | *2-1/4”* | *1”* | *2-1/4"* |
| **2** | *1-1/2”* | *1”* | *1-5/8”* |
| **3** | *1-1/4”* | *1”* | *1-1/2”* |
| **4** | *1”* | *1”* | *1-1/4”* |
| **5** | *3/4”* | *1”* | *1-1/8”* |
| **6-7** | *3/4”* | *3/4”* | *1”* |
| **8** | *1/2”* | *3/4”* | *1”* |
| **9** | *3/4”* | *3/4”* | *1”* |

[1]Except as limited by §213.57(a), where the elevation at any point in a curve equals or exceeds 6", the difference in crosslevel within 62' between that point and a point with greater elevation may not be more than 1-1/2". (Effective one year after effective date of this rule) However, to control harmonics on jointed track with staggered joints, the crosslevel differences shall not exceed 1-1/4" in all of 6 consecutive pairs of joints, as created by 7 low joints. (See diagram below.) Track with joints staggered less than 10' shall not be considered as having staggered joints. Joints within the 7 low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.

(c) The basic tools for determining correct track surface are the standard track level and string line. The track level should be checked by the Supervisor-Track periodically and by the Foreman-Track, or employee inspecting track, each day it is used. If found to be incorrect, it must be accurately adjusted or replaced. Other approved devices may be used for determining crosslevel, but their accuracy should be determined by comparison with a standard track level in correct adjustment.

(d) When surfacing or raising track, one rail, which shall be the lower rail on curves and usually the line rail on tangents, shall be selected as the grade rail. The other rail must be brought to surface by adjusting the crosslevel as needed.

**§64.0 (M) Maintenance Tamping Operations**

(a) Tamping track causes ballast breakdown; therefore, it should only be performed where it is determined to be an effective solution. Lifts of less than 1" should be avoided, as they are less durable and quickly settle under traffic.

(b) When alignment and/or surface are to be corrected by use of mechanical tamper:

   i. Surveying equipment, rail-mounted telescope, or a computer-based measuring system or a long base automatic reference system should be used to determine the corrections of alignment and/or surface.

   ii. The string line method can be used to determine the alignment and to calculate the required corrections or throws of curves.

(c) When track is given a general raise, both rails should be raised at the same time. When track jacks are used, they should be placed opposite each other, and must not be placed between the rails except when necessary.

(d) Adequate ballast shall be distributed in advance of tamping to ensure required lifts can be achieved.

(e) Tamping track must be performed in accordance with Amtrak's Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR.

**§64.1 (M) Special Attention**

(a) Special attention must be given to the surface and line of track at the ends and approaches of bridges, crossings and platforms.

(b) In overhead electrified territory, care must be exercised to avoid reducing clearance between the top of rail and contact wire at established low points, or to establish new low points. Advance notice must be given to the Electric Traction Department and Deputy Chief Engineer- Track when it is necessary to raise tracks under overhead structures or low spots under the catenary system. The ET Department must be notified if tamping operations require any lifts or throws, including changes in superelevation.

(c) When tamping within interlocking, through C&S appliances, or track detection mounted equipment. The C&S Department must be notified prior to any work and all C&S appliances must be moved or removed to allow for proper tamping operations. Notify the C&S Department immediately if damage occurs.

(d) If a tamper with a computer-based measurement system performs the lifting and lining, lifts and throws may be programmed and executed automatically, after being verified by an MW1000 qualified employee, ensuring compliance with geometry requirements for track speed and physical clearances of surrounding infrastructure.

### §65.0(M) Ride Quality (Accelerometer)

The following action is required after measurement of lateral and vertical acceleration by an on-board ride quality computer (accelerometer).

| Acceleration Maintenance Limits | |
|---|---|
| **Accelerations** | **Action** |
| .25g - .39g Lateral<br>.40g - .55g Vertical | Field verify and correct deviations from standards as required. |

## Subpart D(M) - Track Structure

### §101.0(M) Material

### §101.1(M) General

Included in "track structure" are: sub-ballast, ballast, ties, rails, rail fastenings, turnouts, track crossings, and other track materials (OTM).

### §101.2(M) Handling and Care

(a) Moving materials from place to place and care of materials on hand is costly. For these reasons, the amount of material on hand and the number of handlings should be kept to a minimum. This requires careful planning of work, elimination of as much of emergency and non-programmed work as possible and close cooperation with the Material Control Department.

(b) Threaded and/or insulated materials and parts should be protected from the weather. If exposure to the weather is unavoidable, threaded materials should be coated with a protective oil.

(c) When materials are distributed along the track that may present a tripping hazard, a message stating their location shall be sent to the General Superintendent, in order that employees may be notified.

(d) Other track materials should be distributed as near as possible to where they will be used, taking care to keep them off tops of ties, out of the cribs and from getting buried or lost. Material shall not be unloaded between the rails.

(e) Track materials distributed for maintenance work shall not be placed in the gage of live track.

(f) Wherever possible, CWR distributed for installation must be clear of live track tie ends. The ends of CWR strings shall be tapered away from the live track. CWR shall not be unloaded and stored in the gage of live track.

### §101.3(M) Classification

Materials are considered to be in one of the following conditions:

(a) New - Unused, as manufactured or modified.

(b) Rehabilitated - Materials removed from track upon which work has been performed since removal as:

    (1) Reformed rail anchors

    (2) Rebuilt frogs, switches and crossings

(c) Fit - Usable (second-hand), as removed from track with no work performed upon it, as fit rail (relay rail).

(d) Scrap.

## §103.0(M) Ballast

### §103.1(M) General

(g) Unless it is otherwise structurally supported, all track must be supported by material that will:

    (1) Transmit and distribute the load of the track and railroad rolling equipment to the subgrade
    (2) Provide restraint for the track in lateral, longitudinal and vertical directions
    (3) Provide drainage for the track structure
    (4) Facilitate maintenance of track crosslevel, surface, and alignment

(h) Ballast shall conform to Engineering Specification Nos. 200 and 201 and may be obtained only from approved quarries.

(i) Crushed stone shall be used for ballast, except that ballast other than stone ballast, may be used at locations specifically approved by the Deputy Chief Engineer- Track.

(j) The class and size of ballast to be used for the various lines and tracks shall be determined by the Deputy Chief Engineer-Track.

(k) When ballast received is of inferior quality, has improper grading, or contains organic matter, a report shall be made to the Division Engineer so that corrective action may be taken.

(l) If ballast is shipped under weight agreement, the Division Engineer should arrange for periodic checks of weight to protect against shortages or overloading of cars.

### §103.2(M) Distribution

(a) To the extent practicable, ballast should be unloaded in position for use with a minimum of redistribution and dressing, using ballast cars when available.

(b) Ballast must be distributed or immediately dressed so that ample clearance below top of rail is provided for rolling equipment, switches are not fouled, and guard rails are unobstructed.

(c) Immediately remove ballast from bridge walkways, station platforms, grade crossings, and any part of turnouts that interferes with their use. When unloading on under-grade bridges take necessary precautions to protect any highways, pedestrian paths or other public access below from falling ballast and debris.

(d) Ballast level must be watched carefully in all cars and not allowed at any time to drop more than 4' below the ballast level on the other side of car. See Engineering Practice No. 202.

### §103.3(M) Cross Section

(a) Ballast and sub-ballast cross sections should conform to Standard Track Plan AM 70003.

| | |
|---|---|
| Jointed Rail 6" shoulder | 2:1 slope |
| CWR 12" shoulder | 2:1 slope |

### §103.4(M) Ballast Cleaning

When ballast in track becomes fouled, it should be mechanically cleaned to restore proper drainage. The type of cleaning procedure employed should depend on the nature and extent of the fouling.

(a) Shoulder ballast cleaning will promote lateral drainage of the track structure. A proper cycle of shoulder cleaning can aid in extending the cycle between undercutting operations.

(b) Undercutting is a means of cleaning the ballast under the ties as well as the crib ballast.

**§103.5(M) Size and Gradation**

(a) AREMA No. 3 or 4A are the standard specifications of crushed stone used for ballast per Engineering Specification No. 200.

(b) In areas such as tunnels, where there is restricted clearance for lining and surfacing track, AREMA No. 4 ballast per Engineering Specification No. 200 may be used only with the approval of the Deputy Chief Engineer-Track.

(c) In areas where good footing is required as approved by the Deputy Chief Engineer-Track, AREMA No. 5 ballast may be used per Engineering Specification No. 201. Because of its size, AREMA No. 5 ballast is not allowed to be used on main line tracks and in restricted tunnel clearance areas.

(d) Ballast sizing is shown in the table below:

| AREMA reference | Nominal Size | Amtrak Reference | Area of Use |
|---|---|---|---|
| AREMA No. 3 | 2” to 1” | Engineering Specification 200 | Standard for Mainlines |
| AREMA No. 4A | 2” to 3/4” | Engineering Specification 200 | Standard for Mainlines |
| AREMA No. 4 | 1-1/2” to 3/4” | Engineering Specification 200 | Restricted Clearance Areas |
| AREMA No 5 | 1" to 3/8" | Engineering Specification 201 | Other than Mainlines where good footing is required |

**§103.6(M) Ballast; Disturbed Track**

Refer to Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR as required by 49 CFR §213.118.

**§109.0(M) Crossties**

**§109.1(M) Specification**

(a) Wood crossties shall be in accordance with Engineering Specification No. 1907 for Purchase of Wood Crossties & Switch Ties.

(b) Concrete crossties shall be in accordance with Engineering Specification No. 10 for Concrete Crosstie and Fastening Assembly.

**§109.2(M) Installation**

(a) Wood Crossties

(1) Ties should be placed in track with the wider heart wood face down and square to the line of the rail.

(2) The ends of standard 8'-6" ties should be brought to a uniform line 18-1/2" from

the edge of the base of rail on the line side as follows:

(a) On single-track roads, and in tracks of unassigned direction, line the right hand ends of ties going north or west.

(b) On roads with two or more main tracks, line the right hand ends of ties going in the assigned direction of traffic.

(c) Exceptions may be made where, in the use of tie installation machinery, it is advisable to line the opposite ends or where it is desired to retain an existing line side.

(d) When necessary to use shorter than standard length ties, they shall be centered in the track.

(b) Concrete Crossties

(1) Specialized lifting equipment is needed to install concrete ties.

(2) Concrete ties shall be replaced in kind and not intermixed with wood crossties, except in emergency. The intermixed wood ties shall be removed and replaced with concrete ties within seven days.

(3) Intermixing wood crossties and concrete ties shall not be done without approval from Deputy Chief Engineer-Track.

(c) All Crossties

(1) Ties shall be kept sufficiently spaced and square to the line of rail to permit proper tamping. When necessary, ties should be re-spaced as track is rehabilitated by gangs equipped with suitable machinery.

(2) Crossties shall be properly tamped in the area under the rails to avoid center bounding ties.

(3) In third rail territory, the distance between third rail bracket ties will govern intermediate tie spacing. Power rail supports are spaced at every fifth wood tie and every fourth concrete tie, unless otherwise approved by Deputy Chief Engineer-Track.

**§109.3(M) Damage to Ties**

(a) All Crossties:

(1) When handling or spacing ties, care shall be taken not to damage them with picks or spiking hammers. Tie tongs, lining bars, other suitable tools or tie spacing equipment shall be used.

(2) For additional information on fastener application, see §127.0(M).

(b) Wood Crossties:

(1) When performing track maintenance, treating fewer than three adzed ties is impractical. When performing production work, all adzed ties should be treated by an approved method.

(2) Only sufficient adzing to obtain a sound and true bearing for the tie plate shall be done.

(3) Standard tie plugs, or other means approved by the Deputy Chief Engineer-Track, must be used to fill holes when spikes or lags have been drawn.

(c) Concrete Crossties:

(1) Concrete ties are easily damaged by mishandling. They must only be handled

with equipment or tools intended for the purpose. Care must be exercised to ensure that they are not dropped. Sledges or spike mauls must not be used to align concrete ties. Lining bars may be used to align them provided the concrete ties are not struck with the bars.

(2) Concrete ties must be properly supported in the area under the rails before equipment is permitted to operate over them.

(3) Care must be exercised to avoid striking concrete ties when applying or removing elastic fasteners.

(4) Holes may not be drilled in or attachments made to concrete ties unless approved by the Deputy Chief Engineer-Track.

**§109.4(M) Bridge Timber**

(a) Oak ties shall be used on all open deck bridges.

(b) Bridge ties shall be adzed, framed and sized according to framing plans prior to treatment. Suitable holes must be bored for drive spikes that fasten tie spacing bars on timbers. Where ties are bored or dapped in the field, they shall be treated in an approved method.

(c) For typical installation data see Standard Track Plan AM 79401. The size of bridge ties shall be in accordance with Engineering Practice No. 1902.

**§113.0(M) Rail**

**§113.1(M) General**

As used in these instructions, jointed rails are conventional rails bolted together. CWR are rails fabricated into strings longer than 400'.

**§113.2(M) Maintenance Wear Limits for Rail**

**§113.2.1(M) Head and Gage Face Wear**

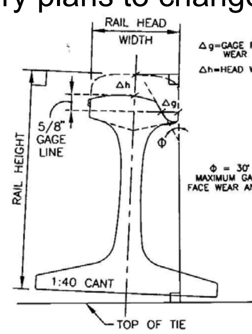
(a) With traffic, the rail head wears vertically and horizontally. As this wear increases, the cross section of the rail decreases. This decrease in rail section will overstress the rail causing rail failure.

(b) Rail shall be scheduled for replacement when gage face or vertical wear are equal to or greater than 3/8" from original rail contour.

**§113.2.2(M) Gage Face Wear Angle**

(a) When a rail is placed in track, with traffic, the gage face wears at an angle (Φ). As this angle increases, the possibility for a wheel to climb the gage face of a rail increases.

(b) As shown on the following diagram, rail replacement shall be accomplished when the face wear gage angle (Φ) exceeds 30°. As the rail wear readings approach 30°, the Division should make necessary plans to change out the rail.



(c) For field verification of gage face wear angle, contact the Office of the Deputy Chief Engineer-Track.

### §113.3(M) Classifications and Identification

#### §113.3.1(M) By Service Developments - Failed Rails

(a) Rails removed from track on account of any defects listed in §213.113(a), except end defects described in paragraph (c) below, must have the top of the rail head noticeably damaged, using a cutting torch or power saw so that they will not be mistakenly returned to service in track.

(b) Failed rails, damaged as above, are to be classified as scrap.

(c) Rails removed from track on account of end defects, such as a bolt hole crack or head-web separation where a portion of the rail end is not physically broken out, must have the top of the rail head noticeably damaged at the location of the defect, using a cutting torch or power saw to ensure that a rail of this type is not returned to service without cropping off the defective end.

### §113.4(M) Service Assignments

#### §113.4.1(M) New Rails

| Class of Rail* | Use |
|---|---|
| No. 1 Rail | In all tracks except in turnouts and special trackwork. See Engineering Practice No. 1605. |
| Head-Hardened Rail or Fully Heat-Treated Rail | For turnouts, special trackwork and curve track as per Engineering Practice No. 1605. |

* No. 1 Rail - prime rail that conforms to latest AREMA Specifications.

* Head-Hardened Rail - prime rail that is fully quenched and tempered in the head area only to increase hardness and strength. Head-hardened rail rolled by PST (Bethlehem Steel Company) will be marked "HH" to the right of the heat number. Head-hardened rail rolled by Rocky Mountain Steel Mill (CF&I Company) will be marked "DH" to the right of the heat number.

* Fully Heat-Treated Rail - prime rail that is fully quenched and tempered to increase hardness and strength. Fully heat-treated rail rolled by PST (Bethlehem Steel Company) will be marked "FT" to the right of the heat number.

* Head-hardened and fully heat-treated-rail markings furnished by any other manufacturers shall be identified by the Deputy Chief Engineer-Track.

#### §113.4.2(M) Cropped or Fit Rails

(a) Rails removed from track having only end defects, such as bolt hole cracks or head-web separations within joint bar areas, may be used without restrictions after defects have been eliminated by cropping.

(b) Fit rail for relaying should be graded and marked according to its physical condition and classified for reuse in accordance with §113.6(M).

### §113.5(M) Disposition and Shipment

(a) Rails released from renewals and retirements must be disposed of as authorized by the Deputy Chief Engineer-Track.

(b) All rail anchors must be removed from rails before loading rails into cars.

(c) For shipment, rails of any weight or classification may be loaded head up in the same car with wood stripping between layers, (except that medium manganese rail must be identified and loaded separately).

(d) Rails shipped for direct reuse must be loaded head up in cars with wood strips between layers and must be examined by the Supervisor-Track to assure that the rails are suitable for the reuse intended.

### §113.6(M) Grading and Marking Rail for Reuse

(a) The suitability of rail for reuse will be determined on the basis of physical condition by designated inspectors.

(b) Rails containing recognizable flaws or damage not eliminated by cropping will be scrapped.

(c) Plug rails will be checked for vertical wear at one location approximately 4' from the end with an approved gage. CWR will be checked for vertical wear throughout the length of rail. Rail will be marked with stripes across the head to show vertical headwear as follows:

| | |
|---|---|
| 1 Stripe | 1/32" |
| 2 Stripes | 2/32" |
| 3 Stripes | 3/32" |
| 4 Stripes | 4/32" |
| 5 Stripes | 5/32" |
| 6 Stripes | 6/32" |

(d) Fit rail to be laid for operating speeds above 90 MPH shall have no more than 1/8" vertical and 1/8" horizontal head wear on one side only (measured 5/8" below top of rail). Rails containing defects shall not be reinstalled in main track.

(e) Fit rail to be laid in all other main tracks shall have no more than 3/16" vertical and horizontal head wear.

(f) Fit rail for yard and siding shall have maximum vertical head wear of 3/8" and 1/4" horizontal head wear on either side (maximum combined horizontal wear of 1/2"). Acceptable rail wear limits for maintenance-of- way facilities shall be determined by the Assistant Division Engineer or Engineer of Track. All other rail is scrap.

(g) Rail shall have been tested in accordance with EP 1811.

(h) Before cropping, rail will be visually inspected for defects. Damaged rail and rail with bends, cuts or engine burns shall be rejected.

(i) No rail shall be less than 34' after cropping if the rail is to be used for CWR.

### §113.7(M) Transposing Rail on Curves

(a) Rail shall not be transposed into Track Classes 7 through 9.

(b) To increase the service life of rails on curves, the high and low sides may be transposed before horizontal wear, vertical wear or flow of metal in the head makes this impractical because of undesirable rail head stresses.

(c) Transposition is to be performed only for rail with light vertical wear ($\Delta h$) of less than 1/4".

(d) Transposition limit is set at 70% of the maintenance side wear limit value (∆g). See the following table:

| Rail Transposing Wear Limits | | | |
|---|---|---|---|
| Rail Section | New Head Width [1] (inches) | If Vertical Wear is <1/4"<br>Maximum Side Wear (∆g) (inches) [2][3] | New Rail Height (inches) |
| 107 NH | 2-5/8 | 3/8 | 6-1/8 |
| 112 RE | 2-11/16 | 3/8 | 6-5/8 |
| 115 RE | 2-11/16 | 3/8 | 6-5/8 |
| 119 RE | 2-5/8 | 3/8 | 6-13/16 |
| 127 DY(M) | 2-15/16 | 7/16 | 7 |
| 130 PS | 3 | 7/16 | 6-5/8 |
| 131 RE | 3 | 7/16 | 7-1/8 |
| 132 RE | 3 | 7/16 | 7-1/8 |
| 136 RE | 2-15/16 | 1/2 | 7-5/16 |
| 140 RE | 2-7/8 | 9/16 | 7-5/16 |
| 152 PS | 2-15/16 | 5/8 | 8 |
| 155 PS | 2-7/8 | 5/8 | 8 |

(1) Head width at the gage line at 5/8" below top of rail.

(2) Side wear includes the total gage face and field face wear as found in transposed rail.

(3) See "Rail Wear Criteria" figure.

### §113.8(M) Distribution

(a) Rails should be unloaded in position for laying to minimize further handling.

(b) Rails should be placed parallel with the track and base down, avoiding excessive bending or damage. Care should be taken to avoid placing rails on manhole covers or close to air lines.

(c) CWR ends must be offset and blocked to allow for thermal expansion.

(d) In yards and at locations where employees must walk close to the track, rail should be placed as near to the ends of ties as possible to avoid obstructing the walkway area.

### §113.9(M) Preparation and Care

(a) Track should be placed in good line and surface prior to rail renewals. Track to be laid with CWR must have standard ballast section for welded rail. Programmed tie renewals should be completed in advance of rail laying.

(b) Rails should be examined for defects and damage prior to laying in track.

(c) At the time of installation, care should be taken so that no damage to rail or fastenings will result. Loose ties should be tamped to a full bearing under the rail immediately behind rail laying operations.

### §113.10(M) Laying Jointed Rails

(a) Jointed rails should be laid, one at a time, with space allowance for expansion being provided between rail ends in accordance with the following tables:

**33' Rails**

| Rail temperature (°F) | Rail End Space (inches) |
|---|---|
| Below -10 | 5/16 |
| -10 to 14 | 1/4 |
| 15 to 34 | 3/16 |
| 35 to 59 | 1/8 |
| 60 to 85 | 1/16 |
| Over 85 | None |

**39' Rails**

| Rail temperature (°F) | Rail End Space (inches) |
|---|---|
| Below 6 | 5/16 |
| 6 to 25 | 1/4 |
| 26 to 45 | 3/16 |
| 46 to 65 | 1/8 |
| 66 to 85 | 1/16 |
| Over 85 | None |

**81' Rails**

| Rail temperature (°F) | Rail End Space (inches) |
|---|---|
| Below 35 | 5/16 |
| 35 to 47 | 1/4 |
| 48 to 60 | 3/16 |
| 61 to 73 | 1/8 |
| 74 to 85 | 1/16 |
| Over 85 | None |

**Greater Than 81' and Less Than 400' Rails**

Rails greater than 81' and less than 400' must be temperature adjusted and anchored as CWR in with Amtrak Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR

(b) To ensure the required space allowance, rail ends should be brought squarely together against approved expansion shims of proper thickness and the rail joints bolted before spiking.

(c) Space between rail ends in insulating joints should only be sufficient to permit insertion of standard end posts.

(d) An approved rail thermometer shall be used. The supervisor in charge shall see that rail temperature is checked frequently and that proper rail expansion shims are used.

(e) To prevent short warp, rails should be laid so that the joints of one line of rails are opposite the half point of rails in the other line with permissible variations as follows:

(1) When possible, the staggering of joints on one side should not vary more than 18" in either direction from the half point of the opposite rail.

(2) Rails laid in accordance with former standards need not be relocated until out-of-face rail renewals are made.

(3) Where approved by the Deputy Chief Engineer- Track, and protected by a 30 MPH speed restriction, joints on tangents in newly constructed track laid by the panel method, other than main track, may be left equal and opposite. When possible, joints on curves should be staggered in accordance with paragraph (1) above.

(f) It is the goal of the Engineering Department to have no jointed rails in track less than 39' in length. Rails less than 18' in length should not be used in main tracks.

(g) In some situations, it may not be possible to install a 18' rail. Under the following conditions rails with a minimum length of 14' may be used:

(1) Connections within turnouts and crossovers

(2) Temporary closures

(3) Temporary replacement of broken rails

(h) Existing short rails, greater than 14' in length, need not be removed until the rails are changed or re-laid.

(i) If possible, when laying rail, avoid placing bolted joints in or closer than 120' to the edges of road crossings, or closer than 20' within the limits of switch rails, guard rails, ends of open floor bridges, concrete deck track, trestles or viaducts.

(j) Rails of the same section should be used on open floor structures, through road crossings and paved track areas of station platforms, and to the greatest extent possible in turnouts and crossovers.

(k) Rails of unequal wear and different sections must be brought to an even surface at joints. If the difference in height of rails must be run off by the use of shims, wood or metal shims of proper thickness, with holes provided for spikes that are of ample size to permit secure fastening to the ties, must be placed between the tie plates and ties. When shimming is performed, the requirements of §129.0(M) and 131.0(M) must be met.

**§113.11(M) Bolt Holes**

Holes must be provided in accordance with standard plans and the following practice:

(a) When holes are necessary, they must be drilled. Bolt holes should be drilled with the joint bars removed or before their application, either by marking the location of the center of the hole, preferably with a proper size template block and center punch (if applicable) and placing the cutting tool directly against the web of the rail, or by drilling through an approved template.

(b) When bolt holes are drilled, a uniform feeding pressure should be maintained and then reduced as the cutting tool cuts through the opposite side of the web. Forcing the cutting tool may produce a ragged hole, with the possibility of bolt hole cracks. Lubricant should be used throughout this operation.

(c) After drilling is completed, bolt holes should be brushed out and inspected. Any burrs or chipped edges should be removed by grinding or filing to a smooth edge around the entire circumference of the hole.

(d) The distance from the end of a rail to center of first bolt hole must not be less than twice the diameter of the hole, except where the standard plan for that rail provides for a lesser distance.

(e) The distance between centers of any two holes of the same diameter must not be less than four times the diameter of the hole; in the case of holes of different diameters, the distance between centers must not be less than 3-3/4 times the average diameter of the two holes.

(f) Bolt holes must be drilled in accordance with the Standard Tack Plans.

(g) The connection between rail ends should be made with fully bolted joint bars, except in non-controlled sidings, yard tracks, and temporary closures where the rail ends may be welded. In those cases, rail ends shall be bolted with two bolts in each rail end.

(h) When it is necessary to use a cut rail at a compromise or insulated joint location, the mill or shop drilled end of the rail should be placed in the compromise or insulated joint. The bolt holes must be accurately drilled in accordance with provisions this part.

**§113.12(M) Cutting Rail**

(a) The tools that may be used for cutting rails are listed below:

(1) Power saws with approved guide attachments

(2) Gas cutting torches, in emergency only in accordance with §213.122.

(b) Gas or electric arc welding is prohibited on any portion of the rail, except as listed below:

(1) Welding of engine burns in accordance with Engineering Practices

(2) Application of welded bonds

(3) Top of rail within limits of joint bars

(c) Any rail damaged by torches must be promptly removed from track.

**§113.13(M) Rails Bonded for Track Circuits**

(a) Where rails are bonded for track circuits, no rail bonds shall be broken or rails removed, except in an emergency, unless a signal maintainer is present and that material to bond the new rail is available.

In case of an emergency, a broken rail, or switch or frog may be renewed without waiting for the signal maintainer. In such cases, the joints shall be tightened to make as good contact as possible with the rails and the signal maintainer notified that the rail bonds have been broken. However, if such work is within the starting circuit of automatic highway crossing protection, the track shall not be restored to service until all trains approaching the crossing have been instructed to be prepared to stop prior to passing over the crossing involved or until crossing protection is provided.

(b) In electric traction territory, care shall be exercised to ensure that at least one return path for electric traction current is maintained before disconnecting leads of impedance bonds or removing rails, frogs, etc. When making rail renewals, etc., before the rail is disconnected, a return path for current shall be provided by using a temporary bond across the track each side of the section of rail to be removed, making sure that no insulating rail joints interfere with this cross-bonding circuit. In emergencies, when the signal maintainer is not present, he shall be notified that the rail bonds have been broken.

(c) Care should be taken to avoid shunting of track circuits with tools, jacks, lining bars, claw bars, tapes or other material carried or laid across the rails.

## §114.0(M) Rail Grinding

(a) Rail grinding can be accomplished with profile grinders or production grinding units. Hand grinding should be limited to small areas where the use of profile grinders is not practical. Out-of-face grinding must be performed with production grinding units.

(b) Production grinding of rail shall be performed at regular intervals based on the condition of the rail, the number and type of trains and the accumulated tonnage at a particular location.

(c) Production grinding is required on all new rail installations to remove surface mill scale and impurities that can grow into surface defects.

(d) Amtrak research has developed three rail profile shapes to be used on main line trackage. These are labeled CPC, CPF, and HRC. These profiles should be applied to all new rail installations as prescribed by the DCE Track.

(e) All Class 8 track must have the CPF profile. This requires rail grinding to achieve this shape. When 400' and greater lengths of new rail are installed in these territories, reduction to Class 7 is mandatory until the production rail grinder can achieve the CPF profile.

(f) Production grinding is required to control and/or remove surface anomalies on the rail head and to remove surface conditions that cannot be readily removed with the profile grinder used for maintenance grinding.

(g) Production rail grinding is required to remove flow and to restore the gage corner and head radius of the rail. See Standard Track Plans for rail head and corner radii.

(h) Production grinding shall be used to remove such surface conditions as flakes, checks, shells, and corrugations.

(i) Production grinding shall be used to control rolling contact fatigue (RCF). By slowing the growth of RCF, the surface defects that arise from it will be eliminated.

(j) Rail grinding on open deck bridges is permitted provided the following conditions are met:

  (1) A qualified individual using a 17-pound dry chemical ABC extinguisher is available to protect against fires.

  (2) A qualified individual must be present for a period of at least two hours after the last field weld is finished and ground.

  (3) An extra 17-pound ABC extinguisher must also be readily accessible as a backup.

  (4) While extinguishing any fires, the qualified individual must stand upwind and aim the chemical at the base of the fire.

  (5) A qualified B&B representative must be present from beginning of grinding process to at least two hours after completion.

  (6) Grinding shall only be performed when there is no highway or river traffic directly under the area of grinding.

  (7) After grinding, the entire structure should be inspected for possible "hot spots" or fire.

### §115.0(M) Rail End Mismatch

Rail shall be maintained so that the mismatch of rails at joints may not be more than that prescribed in the following table:

| Rail End Mismatch Maintenance Limits | | |
|---|---|---|
| | Any mismatch of rails at joints may not be more than the following: | |
| **Class of Track** | **On the head of the rail ends (inch)** | **On the gage side of the rail ends (inch)** |
| 1-3 | 1/8 | 1/8 |
| 4-5 | 3/32 | 3/32 |
| 6-9 | 1/16 | 1/16 |

### §117.0(M) Rail End Batter

(a) Rail end batter is the depth of depression at 1/2" from the end of the rail. It is measured by placing an 18" straightedge on the head of the rail end, without bridging the joint, and measuring the distance between the bottom of the straightedge and the top of the rail end.

(b) When rail end batter is detected, it should be monitored and corrected before reaching the class-specific defect limits given in §213.117.

### §118.0(M) Rail Lubrication

(a) The gage face of all new rail or new trackwork installations that fall under the following categories must be lubricated:

- (1) Running rail in curves greater than 6°
- (2) All switch points and stock rails regardless of turnout size or type
- (3) All frogs through the turnout side only, except No. 26-1/2" and 32-3/4" frogs
- (4) Curved turnout or closure rails (both running rails) for No. 15 and smaller size turnouts
  - (a) Lubrication may include either the outside or inside rail, or both, if both have been renewed. Lubrication will be applied to the renewed steel and approximately 20' beyond in each direction. This lubrication will be reapplied on an every other day cycle for a minimum of 30 days of traffic.
  - (b) Approved curve lubrication grease will be used. It will be applied to the gage face only by liberal brush coat.

### §119.0(M) Continuous Welded Rail

(a) It is important to maintain the desired neutral temperature of CWR so that the track remains stable.

(b) When performing work, it is important to recognize activities that do not change the neutral temperature of CWR or significantly change the neutral temperature of CWR.

(c) All maintenance work regarding CWR must be done in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

**§119.1(M) Use**

(a) CWR fabricated by an approved process may be laid without restriction in fully ballasted tracks.

(b) CWR may be laid across open deck bridges where bridge ties are spaced with timber blocks between ties, provided that the following conditions are satisfied:

   (1) All bridge ties are blocked and are tightly jacked and fastened together with spacing bars secured by lag screws in at least every third tie.

   (2) Bridge ties are securely fastened to the steel structure by means of hook bolts, tie anchors or other approved holding devices.

   (3) The bridge structure is properly anchored to abutments and piers to prevent any movement other than normal expansion.

   (4) CWR is anchored to the bridge ties in both directions in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

   (5) Approved resilient fastening systems shall be used on the running rails of all new bridge timber installations.

(c) After application, approved holding devices must be checked and tightened weekly, until ties have fully seated on top flanges of built-up members.

**§119.2(M) Welding or Bolting CWR**

(a) CWR strings may be field butt welded by an approved method in all classes of track. See §120.0(M), Field Welding.

(b) When field welding is not possible, CWR strings are to be fastened to each other or to other rails with fully bolted rail joints.

(c) If it becomes necessary to apply joint bars temporarily, the end bolt hole in each rail must not be drilled to permit subsequent field welding. Additional rail anchors must be applied to this joint in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR and should be removed after field welds have been made.

(d) Thermite welding shall not be performed within the limits of a highway grade crossing.

(e) Only a power saw may be used to cut rails for thermite welding.

**§119.3(M) Rail Anchoring**

Each CWR string is to be anchored in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

**§119.4(M) Replacement of Defective Rail or Weld**

The entire rail length must be removed where longitudinal defects or transverse defects are involved. All defective rails should be handled in accordance with §113.3.1(M).

**§120.0(M) Field Welding**

(a) The goal of the Engineering Department is to reduce the quantity of joints in track by laying CWR and field welding joints wherever possible.

(b) Thermite and flash butt are acceptable methods for in-track field welding in accordance with EP 2003 and EP 2027.

(c) All new turnouts and special trackwork shall be field welded to include frogs, switch points and stock rails.

(d) If it becomes necessary to apply temporary joint bars, the end bolt hole in each rail must not be drilled as this would prevent subsequent field welding. Additional rail anchors must be applied to this joint in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

(e) Thermite welding shall not be performed within the limits of a highway grade crossing.

(f) Field welding on open deck bridges is permitted provided the following conditions are met:

  (1) A qualified individual using a 17 pound dry chemical ABC extinguisher is available to protect against fires.

  (2) A qualified individual must be present for a period of at least two hours after the last field weld is finished and ground.

  (3) An extra 17 pound ABC extinguisher must also be readily accessible as a backup.

  (4) While extinguishing any fires, the qualified individual must stand upwind and aim the chemical at the base of the fire.

  (5) A qualified B&B representative must be present during the entire welding operation from beginning of welding process to at least two hours after the last field weld is finished and ground.

  (6) Flash butt welding, shearing and grinding shall only be performed when there is no highway or river traffic directly under the area of the welding.

  (7) Bridge timber spacing may be more restrictive than that of ballasted track. Welding shall not be performed if the tie crib is less than 5-1/2" in width.

  (8) Welds on open deck bridges must be made as close to the center of the crib as possible. The minimum distance between center of weld and edge of tie shall be 2-3/4".

  (9) After welding, the entire structure should be inspected for possible "hot spots" or fire.

(g) Field welds shall be located as follows:

  (1) At least 14' away from a field weld or joint in the same rail

  (2) At least 4' from a plant weld in the same rail

  (3) At least 14' from a bonded or insulated bonded joint

  (4) At least 20’ away from a change in type of track construction, such as but not limited to: wood tie to concrete tie, ballasted track to open deck bridge, ballasted track to direct fixation.

(h) When the above minimum distances are not met, correction shall be made by installing a plug rail. The rail should be cut to a length that will ensure placement of the weld in the center of the crib. If a weld cannot be made at the center of a crib, the weld may be located at a minimum of 2-3/4" from the nearest tie or tie plate, whichever is closer. If the above conditions cannot be met, ties shall be respaced.

(i) In no case will a field or plant weld be made within 6" of a bolt hole.

(j) Welds in new turnouts may not conform to the above standards in all locations. However, every effort should be made to use the above standards.

### §121.0(M) Rail Joints

(a) Rail ends shall be fastened together by bolted standard, compromise, insulated, or glued joints.

(b) The use of shims or spring washers between the web of the rail and the joint bar to align the gage sides of rail heads is prohibited.

(c) The use of acetylene torches or grinding to manufacture or change the dimensions of compromise joint bars is prohibited.

(d) Compromise joint bars of an approved design shall be used to join rails of different size.

(e) If rail end mismatch exists after applying approved joint bars, the rail head and gage face surfaces may be adjusted by welding the smaller rail and grinding to finish the weld.

(f) Each rail joint, insulated joint, and compromise joint must be of a structurally sound design and dimensions for the rail on which it is applied.

(g) If a joint bar is cracked, broken or because of wear allows excessive vertical movement of either rail when all bolts are tight, the joint bar shall be changed.

(h) In main line track construction with conventional jointed rail, each rail must be bolted with all rail holes filled.

(i) If a permanent connection is made between CWR and bolted rail, all joint bar holes must be filled.

(j) Each joint bar must be held in position by track bolts tightened sufficiently to provide firm support for abutting rail ends and to allow longitudinal movement of rails in the joint to accommodate expansion and contraction due to temperature variations.

(k) In CWR, joints shall be tightened as much as possible, without regard for longitudinal expansion.

(l) When out-of-face, no slip, joint-to-rail contact exists by design or if the joints are frozen, the requirements of this paragraph do not apply. Those locations are considered to be CWR and must meet all requirements for CWR in this Part.

(m) No rail or joint bar having a torch cut or burned bolt hole may be used in track. When new holes are necessary, they must be drilled. Punching, slotting or burning with a torch is prohibited.

(n) No joint bar shall be reconfigured by torch cutting.

(o) If two or more track bolts are changed in a mechanical joint in Track Classes 1-4, then all bolts shall be tightened.

(p) If two or more track bolts are changed in a mechanical joint in Track Classes 5-9, then all bolts shall be replaced within that joint.

(q) When a bolt is changed in a mechanical joint in Track Classes 1-9 or a frog bolt is changed, then all bolts in the mechanical connections shall be re-tightened

(r) The gap between rail ends at any joint must not exceed 1- 3/8”.

(s) When laying track panels or cutting plugs into CWR, joints and/or welds shall be staggered on opposite rails to avoid joints and/or welds located in the same crib.

**§121.1(M) Bolted Rail Joints**

(a) General

(1) Bolted rail joints consist of either head free or head contact standard bars and head contact compromise joint bars held in position by track bolts.

(2) Head free bars must have the inner surface of the head of the bar held tightly against the rail head fillet with the heel of the bar standing out from the base fillet. See Standard Track Plan AM 71381 for an example of a head free joint bar.

(3) Head contact bars must have the top surface of the bar held tightly against the fishing surface under the rail head but away from the rail head fillet area. Bars must be secured in a vertical position to avoid cocking. See Standard Track Plan AM 71160 for an example of a head contact joint bar.

(b) Application

(1) Joint bars shall be applied in accordance with standard plans and specifications.

(2) New bolts, nuts and spring washers should be used when new or fit joint bars are applied.

(c) Head free joints

The following procedure should be followed in applying head free joint bars:

(1) Set bars in position, insert all bolts and apply spring washers and nuts by hand.

(2) Tighten up center two nuts without over tightening to avoid locking the bars in an improper position. Strike the bead on the head of both inside and outside bars at both ends with a sledge to force the inside faces of bars tightly against rail head fillets. Do not strike the toe of the bar as this tends to force the head of the bar outward.

(3) Tighten all bolts, working from center of joint bars outward. During this final tightening, drive the toes of the bars inward by tapping with a sledgehammer.

By following the above procedure, proper contact will be obtained between the inner face of head of bar and the rail head fillet. Also, the heel of the bar will stand out the proper distance from the rail base fillet.

(d) Head contact joints

The following procedure should be followed in applying head contact joint bars:

(1) Set bars in position on rail, insert all the bolts and apply spring washers and nuts by hand.

(2) While tightening the center bolts, see that bars are in a vertical position.

(3) Tighten all bolts working from center of joint bars toward ends, tapping the toe of joint bars with a sledge so that their vertical position is maintained.

(e) Maintenance

(1) To avoid chipping or spalling under service due to overflow of steel, the rail end faces should be crosscut by grinding with a 1/8" wheel to a depth of not less than 3/16" below the surface of the head. The maximum cut should not be wider than 1/8". If the rails are not in contact, the overflowed metal should be removed from both end faces by grinding 1/16" from the ends of both rails.

(2) When bolted joints are applied, other than insulating joints, the bolts should be tightened at the time they are applied, tightened again within a week and again

within a month after application.

(3) Bolts should be tightened periodically at intervals of not more than one year and in all cases following program track raising or surfacing.

(4) To prevent undue rail stress on account of expansion or contraction at the changes of seasons and wide temperature changes, a sufficient number of joint bars should be loosened to permit the rails to adjust themselves, immediately after which bolts should be tightened. Where necessary, a piece of rail should be cut out to avoid buckling of track.

**§121.2(M) Insulating Rail Joints**

(a) Position

For new work or rail renewals in track circuit territory, insulating joints shall be located as follows:

(1) Where track circuits adjoin within limits of interlockings in cab signal territory, electrified territory or in territory where stray current is likely to be prevalent, insulating joints shall be staggered not more than 56" nor less than 24".

(2) To provide for effective electric locking, insulating joints, staggered as prescribed in paragraph (1) above, shall be located with respect to signals as follows:

i. No insulating joint shall be placed less than 5' nor more than 13' in advance of a high signal, except that where there are opposing high signals at the same location, the insulating joints shall be placed as near an equal distance (between) opposing high signal as practicable.

ii. Insulating joints shall be placed as nearly opposite dwarf signals as practicable.

(3) At locations other than those listed above, insulating joints may be staggered not more than 10".

(4) Insulating rail joints need not be specially staggered at the end of a track circuit where there is no adjoining track circuit or fixed signal.

(5) Insulating rail joints in turnouts and crossovers, and at highway grade crossings shall be located in accordance with the applicable Track and C&S Standard Plans.

(6) Insulating rail joints located in accordance with former railroad specifications need not be relocated until rail is renewed.

(b) Application of continuous insulating joints (Block Joint)

(1) Existing block joints should be programmed for replacement with bonded insulated joints or polyurethane bars.

(c) Application of bonded insulating joints (Glued Insulated Joints)

(1) Bonded insulated joints are required on all concrete tie tracks and should be used in all CWR, in accordance with Standard Track Plans AM 71370 and AM 71371.

(2) Conventional rail joints adjacent to bonded insulating joint rails must be field welded.

(3) All bonded insulating joints are to be installed as suspended joints. If it is absolutely necessary to install the insulated joint as a supported joint on a wood crosstie, an approved type of insulated tie plate must be used under the joint.

(4) Double shoulder tie plates must be used on the two wood crossties supporting suspended bonded insulating joints.

(5) Rail holding spike heads must be in reverse position and must be carefully driven to ensure that spike head is not in contact with the bar, which could result in the joint's being short circuited. All bonded insulating joints will have plate holding spikes installed. An approved type of fastener shall be used where insulated joints are installed in concrete crosstie track.

(6) Joints installed with resilient fasteners shall have the correct clips (modified "e" clips) applied to prevent possible damage to the joint.

(7) No attempt should be made to tighten bolts in bonded insulated joints. In the event the bolts in the joint become loose, the joint should be replaced.

(8) Any rail head overflow at a bonded insulating joint is to be removed by grinding. Extreme care must be exercised to ensure that the end post is not damaged. The overflow should be ground only to the rail end, so that the joint gap will not be greater than the original 3/16". A cross grinder/slotter should not be used to remove the overflow.

(9) The bonded insulating joints will be considered as welded rail joints for purposes of compliance with the anchoring requirements of §125.1(M).

(f) Care of joints

If possible, insulated joints should be installed as a suspended joint. Insulated joints should be installed on effective crossties, tamped and with proper ballast section. When repairing continuous insulated joint components, they shall be renewed in their entirety.

(g) Application of Polyurethane Coated Steel Insulated Joints

(1) Bonded insulated joint plugs are the preferred Amtrak standard.

(2) Polyurethane-coated steel insulated joints may be used in yards, sidings, curved leads in industrial sidings from the main track and interlockings where CWR has not been installed.

(3) Polyurethane-coated steel insulated joints may be used permanently on main lines with Track Classes 1-3 speeds where the use of a bonded insulated plug rail is not practical.

(4) In no case will a polyurethane-coated steel insulated joint be installed in tracks where the speed is Track Class 4 and above except as a temporary repair. These temporary joints must be removed within seven days of installation.

(5) Polyurethane-coated steel insulated joints are to be installed as suspended joints.

(6) The top of the polyurethane-coated steel must be set first into the fillet area of the rail, torquing the bolts from the center to the ends.

(7) Reverse rail holding spikes and do not drive up against the polyurethane-coated steel.

(8) A bolt should never be driven through an insulated bushing, as it will destroy the bushing. If rails and joint parts are in correct relative position and the bolt holes lined up, the bolts can easily be inserted by hand.

## §123.0(M) Tie Plates

## §123.1(M) Use

(a) Tie plates shall be installed under running rails on all wood crossties, switch ties and bridge ties.

(b) Only double shoulder tie plates shall be used under CWR.

(c) Tie plates with different cants and flat plates shall not be mixed.

## §123.2(M) Placement

(a) Canted tie plates shall be installed so that the rail cants towards the centerline of track.

(b) Tie plates must be placed square to the base of the rail and no portion or part of the shoulder can be under the base of the rail.

(c) No metal object that causes a concentrated load by solely supporting a rail shall be allowed between the base of the rail and the bearing surface of the tie plate. Examples include tie plate shoulders, spikes, etc.

## §123.3(M) Tie Pads

(a) The use of tie pads, to include open deck bridges, may be used only with the approval of the Deputy Chief Engineer-Track.

(b) Elastomeric tie pads must be used on concrete ties. There are several designs such as those used with the "PR 601A," "e" clip and "fast" clip assemblies. See the Standard Track Plans.

## §125.0(M) Rail Anchors

Each CWR string is to be anchored in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

## §125.1(M) Number Required

(a) A sufficient number of anchors must be applied and, in a manner, to effectively control longitudinal rail movement, as required by §213.125.

(b) Additional anchors must be applied when there is evidence that rails are moving progressively under traffic.

(c) It should be recognized that when track is raised out-of-face, the resistance to creepage is reduced and additional anchors may be required in order to avoid undue movement.

(d) In general, all tracks require a minimum of every third tie to be box anchored.

(e) A fully clipped wood tie, bridge timber, or fully clipped and insulated concrete tie is considered equivalent to a box anchored wood tie.

(f) Rail anchors shall not be used on open deck bridges, trestles or viaducts, except where the deck and bridge meet the requirements of §119.1(M), or their use is approved by the Deputy Chief Engineer-Track.

## §125.2(M) Application

Rail anchors shall be applied as follows:

(a) Anchors shall be applied at both ends and on the same side of the tie. Where special applications may be necessary, other spacing may be used with permission of the Deputy Chief Engineer-Track. Wherever practicable, rail anchors shall be applied from the gage side of the rail.

(b) When laying rail, the necessary anchors shall be applied immediately after rail is adjusted and before trains are permitted to pass over the track.

(c) Anchors should be applied against sound ties.

(d) When ties at a joint cannot be anchored because of interference with a joint bar, there shall be no anchors applied to the affected ties.

(e) Drive on type anchors shall be applied to switch stock rails, applied from the field side of the track. Care must be taken in application of anchors so as not to foul switch rods.

**§125.3(M) Maintenance**

(a) Rail anchors must have full bearing against the tie or tie plate when applied. Where anchors do not have proper bearing against the tie, maintenance must be performed to restore the bearing capacity.

(b) In order to avoid damage, only proper tools or machines should be used in applying and removing rail anchors. Anchors may be moved along the base of the rail with an approved device but should not be driven along the base with a hammer.

(c) Proper opening between rail ends is provided and maintained by the use of adequate rail anchors. Where rail openings are excessive, the rails should be driven back to provide uniform space allowance for expansion, necessary rails of suitable length inserted, and an adequate number of rail anchors applied to hold the rails against running in either direction. Where insufficient expansion allowance has developed so that line kinks can result in hot weather, similar adjustment should be made in order to increase the allowance, inserting shorter rails of suitable length where necessary, again applying sufficient anchors to control creepage.

**§125.4(M) Assignment**

The use of rail anchors should be in accordance with the following service assignment:

(a) Use new or reformed anchors in laying:

    (1) New bolted or continuous welded rail

    (2) Continuous welded fit rail

(b) Use fit anchors if available in:

    (1) Laying bolted fit rail.

    (2) Applying additional or replacement anchors without restriction.

    (3) Spot tie replacement.

**§127.0(M) Track Fasteners**

**§127.1(M) Number Required**

(a) The requirements of §213.127 must be satisfied as to the minimum number and location of effective track fasteners.

(b) Additional fasteners may be used where they are needed to hold gage.

**§127.2(M) Application**

(a) All elastic fasteners shall be inserted into or removed from the cast-in-place shoulder (concrete tie) or tie plate (wood tie) with an approved device such as a "pan- puller" or sledgehammer as appropriate. The use of a spike maul is prohibited.

(b) Elastic fasteners should not be overdriven as overdriving will cause premature relaxation of the fastener. Fasteners that have been overdriven or are not performing their intended function of limiting the vertical and longitudinal movement of the rail shall be replaced.

(c) In the case of the "e" clip, a distance of 3/8" (approximate width of a wooden pencil) between the shoulder and the face of the clip is required to prevent overdriving.

(d) In the case of the "fast" clip, the clip shall be driven or inserted until the clip is engaged in the shoulder notch.

(e) When applying "e" or the "PR 601A" clips with a sledgehammer, the clip must initially be gently tapped to ensure proper insertion before the clip is fully seated. When removing "e" or "PR 601A" clips with a sledgehammer, the clips must initially be gently tapped to remove the toe load to ensure safe removal of the clip.

(f) When installing clips by either the pan-puller or sledgehammer methods, the tie must be flush with the bottom of the rail or assistance will be required to raise the tie so that the pan-setter may be used for clip application.

(g) Care must be exercised so as not to strike the concrete tie or concrete tie shoulder in order to prevent damage to the tie. Striking a concrete tie to make adjustments in the alignment of the tie with any type device is prohibited.

(h) 15/16" diameter coach screws shall be used to secure cold rolled plates (1" diameter holes) with elastic fasteners to wood ties and timber. Coach screws must be screwed into a 11/16" diameter pre-drilled hole, 6" deep. Driving of coach screws with a sledgehammer or spike maul is prohibited.

(i) All spikes shall be driven with the head pointed toward the rail, except spikes against sides of all joints, especially bonded and polyurethane-coated steel insulated joints, shall be driven with the head pointing away from the rail and not in solid contact with the joint bars.

(j) Spikes should not be driven at ends of insulated joints in any manner that would cause the insulated joint bar to become electrically connected to the rail.

(k) Spikes must be started vertically and square and driven straight. The shank of rail holding spikes must have full bearing against the base of rail. Spikes should be driven in accordance with Standard Track Plan AM 72051 being careful not to overdrive. The use of lock spikes (hair pins) is prohibited.

(l) Care must be taken not to strike the rail, its fastenings or signal appliances when driving spikes.

(m) Spikes in main tracks, when throat cut or deteriorated due to rust, should be replaced.

(n) All old spikes, when pulled, shall be picked up, sorted and returned for reuse, if applicable, or scrapped.

(o) Track spikes (cut spikes) shall not be driven into round plate holes.

(p) On all open deck bridge structures, when the head of the track spike is broken off, the replacement spike should be inserted in a new location, leaving the spike stub in the tie. If a new spike location is not available, the stub shall be driven completely through the tie so as to avoid shunting the track circuit.

(q) All old spike holes shall be plugged with treated or cedar wood plugs prior to re-spiking.

**§127.3(M) Rail Fastening Systems**

(a) Track shall be fastened by a system of components that effectively maintains gage within the limits prescribed in §213.53. Each component of each such system shall be evaluated to determine whether gage is effectively being maintained.

(b) When spikes and elastic fasteners are used, unless otherwise ordered by the Deputy Chief Engineer-Track, each rail shall be fastened to every tie in accordance with §213.127.

**§129.0(M) Track Shims**

(a) The use of track shims shall be approved by the Deputy Chief Engineer-Track.

(b) If track does not meet the geometric limits and the working of ballast is not possible due to weather or natural conditions, track shims may be installed to temporarily correct the track surface.

(c) When shims must be installed, speeds may not exceed 50 MPH (F) and 90 MPH (P).

(d) Shimmed track must be watched carefully to see that shims are securely in place and tight, and that proper gage and crosslevel are being maintained. Special attention should be given when frost is thawing, as the action is frequently faster than when freezing.

(e) If shims are used, they must be removed as soon as weather or other natural conditions permit and the track resurfaced.

(f) When shims are used, they must be inserted between the tie plate and the tie.

(g) Tie plates must not be removed from the ties as a means of adjusting the surface or crosslevel of track.

(h) Track shims must be at least the size of the tie plate and be spiked directly to the tie with spikes that penetrate the tie at least 4-1/2".

(i) Shims not exceeding 1" in thickness, in accordance with Standard Track Plan AM 72095, may be used with standard spikes. Special 8" track spikes shall be used where shims thicker than 1" have been authorized by the Deputy Chief Engineer-Track. Shims must be securely attached to ties with 10d or 20d nails, depending on the thickness of the shim.

(j) When a rail is shimmed more than 1-1/2", it must be securely <u>braced</u> on at least every third tie for the full length of the shimming in accordance with the following diagram:

(k) When a rail is shimmed more than 2", a combination of shims and 2" or 4" planks, must be used with the shims on top of the planks, except as provided in §131.0(M).

(l) Track shims should not be left in track for extended periods. They should be removed as soon as possible after the ground or ballast thaws and dries out. Any fouled ballast should be removed, and the track tamped and restored to surface and alignment limits given in the Limits and Specifications for Track Construction.

**§131.0(M) Planks Used in Shimming**

(a) Unless otherwise directed by design or approval from the Deputy Chief Engineering-Track, When planks must be installed, speeds may not exceed 50 MPH (F) and 90 MPH (P).

(b) Planks used in shimming must be at least as wide as the tie plates, but in no case less than 5-1/2" wide. Whenever possible they must extend the full length of the tie. If a plank is shorter than the tie, it must be at least 3' long and its outer end must be flush with the end of the tie.

(c) When planks are used in shimming on uneven ties, or if the two rails being shimmed heave unevenly, additional shims may be placed between the tie plates and the planks under the rails to compensate for the unevenness.

(d) Planks must be secured to the crossties with at least four 60d nails. Planks must be bored with 5/8" diameter holes at locations in accordance with Standard Track Plan AM 72051 before spiking rails or shim braces.

## §145.0(M) Inner Bridge Guard Rails

## §145.1(M) General

(a) Inner bridge guard rails must be properly installed and maintained. Installation shall be in accordance with Standard Track Plan AM 71791 and applicable plans for wood and concrete ties.

(b) A "single" guard rail is a continuous line of rails fastened to ties adjacent to the gage side of one running rail. A "full" guard rail consists of two such lines of rail, one adjacent to the gage side of each running rail.

## §150.0(M) Tool Requirements

See §213.250 for typical tools used in inspection and maintenance.

# LIMITS AND SPECIFICATIONS FOR TRACK CONSTRUCTION

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# LIMITS AND SPECIFICATIONS FOR TRACK CONSTRUCTION
# SUBPARTS A-D
### Track Classes 1-9

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## Subpart A(C) – General

### §1.0(C) Scope of Subpart

(a) Construction is the complete replacement of track structure from subgrade to top of rail. It should always be the goal to complete construction projects to a zero tolerance. This is not always practical given such variables as rail rolling tolerances and manufacturing limitations. Therefore, construction tolerances have been developed.

(b) The construction section provides standards that will be used in conjunction with Standard Track Plans and Engineering Practice for the construction of track. It provides guidance to Engineering Department forces, contractors and others building track. Any portions of this section may be included in a contract and will carry the same force as specifications, when so used.

(c) This section contains "construction limits" that are to be used when constructing track and are not to be confused with the "safety limits" and "maintenance limits" found in this Part.

(d) Except when designated as part of a specification in a contract, it is not the intent of this section to establish arbitrary procedures or values, but to serve as a guide that must be considered in the light of experience and the requirements of the service.

## Subpart B (C) – Roadbed and Right-of-Way

### §33.0(C) Drainage

Drainage is of prime importance for the construction of track. Drainage facilities, at a minimum, shall conform to Standard Track Plan AM 70003.

(a) Drainage ditches shall conform to the following standards:

  (1) Side slopes shall not exceed 2(H):1(V).

  (2) Trapezoidal ditches shall have a minimum bottom width of 2 feet.

  (3) Sloped towards outfall with a minimum grade of 0.25%.

  (4) Steep ditches with high velocity flow should be lined with riprap to minimize erosion and sediment build up.

  (5) Depth shall be sufficient to keep ties dry during major storm events. A minimum of 2 feet from top of tie is recommended.

(b) At locations where flow paths are obstructed by existing infrastructure (e.g. access roads, catenary structures, duct banks) appropriately sized underdrains and/or culverts should be installed to allow continuous flow.

(c) Spoils generated from undercutting, shoulder cleaning, ditching, or other trackwork activities must be distributed properly. Spoils must not be placed in areas that will or have the potential to foul or block drainage, ditches, or existing flow paths.

### §34.0(C) Geosynthetics

Geosynthetics are a range of materials used to enhance the properties of soils. The effectiveness of geosynthetics depends on site-specific conditions and should only be used with the approval of the Deputy Chief Engineer of Track.

(a) Planning and design for use:

  (1) The use of geosynthetic under railway track is dependent upon traffic, environmental and/or subgrade conditions. These conditions should be determined to specify the right type of geosynthetic for the conditions encountered.

  (2) Geosynthetics have numerous types and civil engineering applications as described herein. Examples of these are: embankment construction over weak soils, access road stabilization, retaining wall construction, erosion control and filtration for drains.

(b) Types and applications:

  (1) Geofabrics (also called filter fabric) is a flat material intended to allow water to pass though while retaining fine soil particles. They have no strength properties and are susceptible to puncture damage during installation and use. Geofabrics are typically applied under the sub-ballast in areas with high ground water and competent subgrade materials. This will prevent pumping of fines up from the subgrade to foul the ballast layers and must be paired with adequate drainage.

  (2) Geogrid is a flat material with openings sized to interlock with stone particles used above them. This provides strength to the stone layer in which they are installed. They have no filtering properties and are typically durable against puncture during construction. They are typically installed under the sub-ballast for track over very soft subgrade soils and between the ballast / sub-ballast for track over moderately soft subgrades.

(3) Geoweb (also called geocell) is an expandable material that opens into an array of pockets that comes in a variety of heights. These spread point loads over a wider area and is good for use in very soft subgrades or at chronic profile spots like bridge transitions. The size of the cells and height is dependent upon the stone infill gradation and the loading requirements. This must be stretched open and infilled with clean and compactable stone. Geoweb installations require deeper excavation for installation, protection from damage during construction, and properly compacted infill to achieve desired results.

(4) Geosynthetics can be used in combinations depending on the material properties and desired outcomes.

(5) Other types of geosynthetics are available for use in specific conditions. Their use should be approved by the Deputy Chief Engineer – Track.

(c) General construction guidelines:

(1) Most geosynthetics are susceptible to damage by sunlight and must be kept in the protective wrapper until ready for use. The protective cover must not be removed from the fabric roll until the day it is to be installed. If only a portion of a roll is to be used, the unused portion must be put back in the wrapper. Manufacturer's instructions for proper storage should be followed.

(2) The installation surface shall be prepared and shaped to the line and grade as directed prior to geosynthetic placement. Special attention shall be given to eliminate any sag pockets in the roadbed and to facilitate drainage away from the track centerline.

(3) The geosynthetic shall be stretched taut (both longitudinally and transversely) before backfilling. Special care shall be taken to avoid damage to the geosynthetic during construction. No machinery or vehicles shall be allowed to operate on or across the geosynthetic until backfilled.

(4) Geosynthetic sheets should overlap between 18 to 36 inches in accordance with manufacturer’s recommended practices. Overlaps shall be installed at the intersections of all sheets in any direction.

(5) Geosynthetics must be covered the same day as applied. If any length of fabric is overexposed to sunlight, it shall be cut out and reinstalled to meet the overlap requirements as paragraph (4) above.

(6) Holes and tears shall be repaired by a section of the same geosynthetic fabric as described in paragraph (4) above. Care must be taken to ensure that the patch will remain in place during backfill.

(7) Ballast materials shall be tamped by setting the tamper tools to a minimum depth and using the minimum pressure required to compact the ballast without puncturing the fabric.

**§35.0(C) Cross Section**

Roadbeds, embankments, and excavations should be constructed and maintained in accordance with Standard Track Plan AM 70003. Any deviations shall be approved by the Deputy Chief Engineer-Track.

### §37.0(C) Vegetation

(a) Growth of small vegetation should be encouraged on slopes of embankments, cuts and deep ditches to prevent erosion. Vegetation control efforts should be limited in areas of recent earthwork during the growing season while vegetation growth is being established. If vegetation can't be established, additional erosion control efforts should be installed (e.g. riprap, geosynthetics, gabion baskets, netting).

(b) Vegetation growth must be controlled in accordance with the requirements of §213.37.

### §39.0(C) Signs and Posts

Track signs and posts must be placed and maintained in accordance with Standard Track Plans and special instructions. They should not be installed as to interfere with signals or safety appliances.

### §41.0(C) Highway Grade Crossings

### §41.1(C) Construction

(a) Public and private grade crossings are to be constructed in accordance with Track Standard Plans and Engineering Practices unless otherwise approved by the Deputy Chief Engineer-Track.

(b) CWR shall extend a minimum of 120' on each side of a crossing.

### §41.2(C) Conduct of Work

Work on highway crossings, public streets and roads shall be done with the least inconvenience possible to highway travelers. Care must be taken to protect the work in compliance with local ordinances. When necessary to construct temporary footwalks, safety precautions must be observed.

### §44.0(C) Fencing

### §44.1(C) Right-of-Way Fencing

(a) Fencing shall be for safety and security purposes. For specific design purposes, refer to the Structures Department.

(b) Fencing shall be located 1' inside the property line or at the lease line for leased property.

(c) Gates shall have appropriate locking devices.

### §44.2(C) Intertrack Fencing

(a) Fencing is to be installed between tracks as directed by the Deputy Chief Engineer-Track.

(b) The fence is to be installed as shown on the appropriate Structures Department standard plans and in accordance with the clearance diagram in Standard Track Plan AM 70050.

## Subpart C(C) – Track Geometry

### §53.0(C) Gage

### §53.1(C) Standard for Gage

(a) The standard gage for track, measured between the running rails at right angles to the alignment of the track 5/8" below the top of rail, is 56-1/2". Gage on curves over 13° and through turnouts less than No. 8 will be specified by the Deputy Chief Engineer-Track.

(b) Gage shall be changed by adjustment of the rail opposite the line rail (see §53.1(M)).

### §53.2(C) Construction Gage Limits

(a) Gage shall be measured with a standard track gauge or other authorized devices. These devices must be checked for accuracy prior to daily use.

(b) When constructing or restoring track, provided that the gage is uniform, the following tolerances from standard gage apply:

| Construction Gage Limits | | |
|---|---|---|
| **Class of Track** | **Minimum (inches)** | **Maximum (inches)** |
| **1-3** | 56-13/32 | 56-5/8 |
| **4-9** | 56-13/32 | 56-9/16 |

### §55.0(C) Alignment

(a) Alignment (general) is the physical appearance of the railroad as viewed from above, which consists of a series of straight lengths of track, referred to as tangents, connected by simple, compound and reverse curves.

(b) Alignment (line) is the condition of track with regard to uniformity of direction over short distances on tangents and in curves.

### §55.1(C) Alignment Tolerances for Construction

(a) The following standards shall be used for the construction of new track and restoration of existing track.

| Construction Standard for Tangent and Curved Track | |
|---|---|
| **Class of Track** | **The deviation of the designated mid-ordinate from a 62' chord may not be more than (inches):** |
| **1** | 3/8 |
| **2-9** | 1/8 |

(b) The realignment of track and superelevation on curves in overhead electrified territory must not be changed until proper notice has been given to the Electric Traction Department.

(c) Curve alignment changes must be made in accordance with Amtrak Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR.

(d) Alignments must be maintained within the prescribed limits given above and must meet minimum roadway clearances prescribed in Standard Track Plan AM 70050.

### §55.3(C) Referencing Track for Lining

(a) The following features can be used for referencing the design alignment:
   (1) Survey stakes. Stakes shall be set a sufficient distance from the track to be lined to ensure they will not be disturbed by preparatory work such as regulating of ballast.
   (2) Permanent structures such as: Catenary Poles, Station platforms or Bridge abutments.
   (3) An adjacent track (multiple track territory only). Track center shall be marked on the web of the near rail of the reference track at each station.

(b) Determining Lining Rails:
   (1) Outer rails of curves and field side rails on tangents should be selected as the line rails.
   (2) On single tangent track, either rail may be used as the line rail, however, the north or east rail is the preferred line rail. The same line rail shall be used for the full length of that tangential segment of track.
   (3) For switches or turnouts the rail opposite the point of frog should be used as the line rail.

(c) Existing Track Center Measurements
   (1) Curves shall be measured horizontally from the gage side of the line rail of the reference track to the gage side of the line rail of track to be worked. When necessary, plumb bobs shall be used as a measurement aid.
   (2) Tangents on either side of curves shall be measured using the same reference rail as in the curve.
   (3) In multiple-track territory, an adjacent track shall be used to measure and record track centers for referencing. The track used for referencing shall not be disturbed until the lining operation on the track being worked is completed.
   (4) For switches or turnouts track centers should be taken at point of frog.

(d) Track centers should be recorded at each station of the design alignment. The track used for referencing shall not be disturbed until the lining operation on the track being worked is completed.

(e) If a tamper with a computer-based measurement system performs the lifting and lining, lifts and throws may be programmed and executed automatically.

(f) Track centers should be measured immediately after each pass and compared to the design track centers. Track center measurements should be taken at each design alignment station.

(g) Track center distances in curves shall be measured horizontally from the gage side of the line rail of the reference track to the gage side of the line rail of track to be worked. When necessary, plumb bobs shall be used as a measurement aid.

(h) The track centers for tangents on either side of curves shall be measured using the same reference rail as in the curve.

(i) Lining a curve in CWR territory must be done in accordance with Amtrak's Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR.

## §57.0(C) Curvature, Superelevation and Speed

### §57.1(C) General

(a) Elevation, or superelevation, is the vertical distance of the outer rail of a curve above the inner rail. It is provided to overcome or partially overcome the effects of curvature and speed.

(b) Equilibrium superelevation is that which exactly overcomes the effect of negotiating a curve at a given speed for any given degree of curvature, placing the resultant centrifugal force and weight of equipment in a direction perpendicular to the plane of the track.

(c) Underbalance (cant deficiency) is the amount that a superelevation is less than equilibrium superelevation for any given combination of speed and curvature.

(d) Overbalance is the amount that a superelevation exceeds equilibrium superelevation and is produced by the operation of a train around a curve at less than equilibrium speed or stopping on the curve.

(e) Authorized speed is that specified in the current Employee's Timetable.

### §57.2(C) Superelevation

The Deputy Chief Engineering-Track shall establish the amount of superelevation, underbalance and speed to be placed and maintained on each curve. Design superelevation shall not exceed 6". See Appendix B, Underbalance Tables Maximum Allowable Operating Speeds on Curves.

## §59.0(C) Spirals and Elevation Runoffs

(a) Spirals shall be provided in main tracks at the ends of simple curves and segments of compound curves. Spirals should be provided in other tracks, where practicable, to facilitate curve negotiation by long cars.

(b) A spiral should be used so that the degree of curvature and the amount of elevation at any point will change uniformly.

(c) Elevation runoff must be at a uniform rate and must extend the full length of the spirals. If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, part of the runoff may be made on tangent track, but only with the authority of the Deputy Chief Engineer-Track.

(d) The length of spiral needed to accommodate the minimum elevation runoff may not be sufficient to permit the desired ride quality. The minimum length spiral for comfortable high speed train operation should be determined from either of the following formulas:

  (1) L = 1.63 E – To be used where track center distances and clearances permit.

  (2) L = 1.22 E – To be used where physical characteristics restrict the use of the spiral determined from the formula in paragraph (1), above.

  Where

  L = Minimum desirable length of spiral in feet. $E_u$ = Underbalance in inches.

  V = Maximum authorized train speed in MPH.

### §59.1(C) Rate of Change of Superelevation

(a) The change in superelevation should be in uniform increments, and the rate of change per 31' of track should not be more than the following:

| Construction Change in Superelevation | |
|---|---|
| **Track Class** | **Maximum Rate of Change (inch)** |
| **1-3** | 1/2 |
| **4-7** | 3/8 |
| **8-9** | 1/4 |

(b) At least 100' of tangent track, with zero crosslevel, should be provided between the zero superelevation points in adjacent curves of opposite direction, or facing same hand turnouts where practical.

### §59.2(C) Marking

(a) The degree of curve (degrees-minutes-seconds), radius (feet), required superelevation (inches) and the length (feet) for each segment of a curve shall be designated at the control points of each curve.

(b) When reconstructing existing curves, existing superelevation tags need not be changed until such time as the designated superelevation or spiral lengths for that curve are changed.

### §61.0(C) Clearances and Track Centers

### §61.1(C) Track Centers

(a) In maintaining alignment, the existing track centers, including equivalent centers on curves, must not be reduced below the minimum established for the territory.

(b) A permanent record of track centers between main tracks, and between main and adjacent side tracks, should be maintained by Division Engineers and Deputy Chief Engineer-Track.

(c) For construction, the following track centers should be used on tangent and then increased for curves in accordance with paragraph (d), unless otherwise instructed by the Deputy Chief Engineer-Track.

| Construction Track Centers | |
|---|---|
| **Designation of Tracks (Between:)** | **Track Centers on Tangents** |
| Adjacent Main, Yard, Industrial and Other Side Tracks | 14' |
| Main Track and any adjacent track, other than another main track or a yard ladder track | 17' |
| Secondary, Running, Industrial or Passing Track and any adjacent track, other than a yard ladder track | 17' |
| Yard Ladder Track and adjacent track, except other yard ladder | 18' |
| Adjacent Yard Ladder Tracks | 19' |

(d) On curves, to provide clearance between cars and locomotives equivalent to that obtained on adjacent tangent track, center distances in paragraph (c) should be increased as follows:

  (1) Where the amount of superelevation is the same on adjacent tracks or the superelevation of the inner track is greater than that of the outer track, increase the tangent track center distance 1" for each $0^{o}$-30' of curvature.

  (2) Where the superelevation of the outer track is greater than that of the inner track, the tangent track center distance should be increased 1" for each $0^{o}$- 30' of curvature, plus 3-1/2" for each 1" of difference in elevation of the two tracks considered.

(e) The minimum tangent track center for any location is 12'. In addition, on curves, the 12' minimum track center must be increased as in (d).

**§61.2(C) Intertrack Clearance-Limiting Objects**

(a) For the following signals placed between the tracks, track center distances shall not be less than 25':

  (1) One arm position light signals, where the center of the background is less than 18' above top of rail.

  (2) Two arm position light signals, where a bottom arm other than a marker or vertical aspect is used, and the center of the bottom arm aspect is less than 18' above top of rail.

  (3) Search light or color light signals, where the overall width of the signal is in excess of 24" at any point less than 18' above top of rail.

(b) For signals, other than dwarf and those described in paragraph (a), the track center distance shall not be less than 19'.

(c) For signal bridge supports, pedestal signals or switch stands with intermediate or high staff, the track center distance shall not be less than 19'.

**§61.3(C) Other Clearance-Limiting Objects**

For clearance limiting-objects other than those described in §61.2(M), see Standard Track Plan AM 70050.

**§62.0(C) Grades**

**§62.1(C) Limitations**

No grades exceeding a rate of 2-1/2% shall be designed without the authority from the Deputy Chief Engineer-Track.

**§62.2(C) Grade Compensation for Horizontal Curves**

Where a curve is located on a grade and combined curve and train resistance control the train load, the grade on the curve should be compensated as follows:

(a) The grade on curves should be reduced at the rate of 0.04% for each degree of curvature.

(b) At places where trains frequently stop, the grade should be reduced at the rate of 0.05% for each degree of curvature.

## §62.3(C) Vertical Curves

(a) Where changes in grade occur, gradient lines should be connected by vertical curves, observing the following provisions:

(1) The length of a vertical curve is determined by the difference in grades to be connected and the rate of change adopted.

(2) For high speed main tracks, the rate of change should not be more than 0.05' per station of 100' in sags and not more than 0.10' per station of 100' on summits.

(3) For other main line and secondary tracks, the rates of change may be twice those for high speed tracks.

(4) For tracks of lesser importance, the rates of change may be relatively large but not greater than practical conditions permit.

(b) On curves, the low rail is the grade rail. On tangents, either rail can be used as the grade rail. However, the line rail is often used as the grade rail.

## §63.0(C) Track Surface

## §63.1(C) General

(a) Track surface is the relationship of opposite rails to each other in profile and crosslevel. Track profile is the running surface along the top of the grade rail. Crosslevel is the difference in elevation across opposite rail heads measured at right angles to the track alignment. The ideal surface is a uniform profile consisting of constant grades connected by vertical curves, with zero crosslevel on tangents and predetermined crosslevel on curves.

(b) The profile of track being surfaced should not be raised above established grades, except under instructions from the Deputy Chief Engineer-Track, who will give consideration to the required elevations and clearances in tunnels, under catenary systems and overhead structures, and at interlocking plants, undergrade bridges, platforms and highway grade crossings.

(c) Any encroachment upon the published minimum overhead or side clearances from a track will not be permitted.

## §63.2(C) Construction Limits

(a) The following criteria will serve as a practical guide for providing smooth riding track.

(b) The basic tools for determining correct track surface are the standard track level and string line. The track level should be checked by the Supervisor-Track periodically and by the Foreman-Track, or the employee inspecting track, each day it is used. If found to be incorrect, it must be accurately adjusted or replaced. See Part I, §213.251(i). Other approved devices may be used for determining crosslevel, but their accuracy should be determined by comparison with a standard track level in correct adjustment.

(c) When surfacing or raising track, one rail, the lower rail on curves and usually the line rail on tangents, shall be selected as the grade rail. The other rail must be brought to surface by adjusting the crosslevel as needed.

(d) The construction limits for track surface are contained in the following table:

| Track Surface Construction Limits | | | | |
|---|---|---|---|---|
| | Track Classes | | | |
| Track Surface | 1 | 2 | 3 | 4-9 |
| The runoff in any 31' of rail at the end of a raise may not be more than (inches): | 3/4 | 1/2 | 1/4 | 1/8 |
| The deviation from uniform profile on either rail at the mid-ordinate of a 62' chord may not be more than (inches): | 3/4 | 1/2 | 1/4 | 1/8 |
| The deviation from zero crosslevel at any point on a tangent and designated elevation in curves may not be more than (inches): | 3/4 | 1/2 | 1/4 | 1/8 |
| Except as provided in §59.0(C), the difference in crosslevel between any two points less than 62' apart may not be more than (inches): | 3/4 | 1/2 | 1/4 | 1/8 |

(e) The difference in crosslevel between any two points less than 10' apart is designated as short warp and may not be more than (inches):

| Track Surface | Class of Track |
|---|---|
| Short warp | 1-9 |
| | 1/8 |

**§64.0(C) Construction Tamping Operations**

(a) Surfacing track causes ballast breakdown; therefore it should only be performed where it is determined to be an effective method to set track to the correct design parameters. Surfacing work shall be executed in a manner that assures maximum durability.

(b) Passing lifts of less than 1" should be avoided, as they are less durable and quickly settle under traffic.

(c) Adequate ballast shall be distributed in advance of tamping to ensure required and designed lifts can be achieved.

(d) Tamping track must be performed in accordance with Amtrak’s Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR.

(e) Following tamping operations, ballast dressing must be performed to ensure sufficient cribs and shoulders are established.

**§64.1(C) Special Attention**

(a) Special attention must be given to the surface and line of track at the ends and approaches of bridges, crossings direct fixation, and platforms.

(b) In overhead electrified territory, care must be exercised to avoid reducing clearance between the top of rail and contact wire at established low points, or to establish new low points. Advance notice must be given to the Electric Traction Department and Deputy Chief Engineer- Track when it is necessary to raise tracks under overhead structures or low spots under the catenary system. The ET Department must be notified if tamping operations require any lifts or throws, including changes in superelevation.

(c) When tamping within interlocking, through C&S appliances, or track detection mounted equipment. The C&S Department must be notified prior to any work and all C&S appliances must be moved or removed to allow for proper tamping operations. Notify the C&S Department immediately if damage occurs.

(d) If a tamper with a computer-based measurement system performs the lifting and lining, lifts and throws may be programmed and executed automatically, after being verified by an MW1000 qualified employee, ensuring compliance with geometry requirements for track speed and physical clearances of surrounding infrastructure.

### §70.0(C) Secondary, Yard and Industrial Tracks, and Sidings

### §70.1(C) General

(a) The weight and size of cars and locomotives and requirements for satisfactory negotiation of curves, reverse curves, crossovers, ladder tracks and side track connections by long cars must be considered in the design of all tracks, so that they will not lose their utility for the desired use due to the increasing size of equipment.

(b) New side track designs, including alignment, grade and clearances, shall be approved by the Deputy Chief Engineer-Track.

(c) Unconnected ends of secondary and yard tracks must be curved away from adjacent main tracks.

(d) Where there is danger of injuring persons or property if cars should be run off the end of the track, a bumping post or wheel stop, of approved type, shall be provided. Wheel stops shall not be used on tracks used by passenger equipment.

### §70.2(C) Curvature

(a) No curves shall be constructed or realigned resulting in a greater than existing curvature. Every opportunity should be taken to lessen the curvature in existing track.

The introduction of curvature between the heel of a frog and the last long turnout tie shall be avoided.

(b) In the construction of new yards and side tracks, the minimum radius of curvature shall be 459' (maximum curvature 12º-30') except with special approval of the Deputy Chief Engineer-Track. Recommended tangent distance between reverse curves or facing same hand turnouts is 100'.

### §70.3(C) Spirals

Between reverse curves, where spiral easements have not been provided, and between opposing adjacent turnouts of the same hand, the length of tangent track should be at least 100' or equivalent to the longest car or unit operated over the track.

## Subpart D(C) – Track Structure

### §101.0(C) Material

### §101.1(C) General

Included in "track structure" are sub-ballast, ballast, ties, rails, rail fastenings, and other track materials.

### §101.2(C) Handling and Care

(a) Moving materials from place to place and care of materials on hand is costly. For these reasons, the amount of material on hand and the number of handlings should be kept to a minimum. This requires careful planning of work, elimination of as much of emergency and non-programmed work as possible and close cooperation with the Material Control Department.

(b) Threaded and/or insulated materials and parts should be protected from the weather. If exposure to the weather is unavoidable, threaded materials should be coated with a protective oil.

(c) When materials are distributed along the track that may present a tripping hazard, a message stating their location shall be sent to the General Superintendent, in order that employees may be notified.

(d) Other track materials should be distributed as near as possible to where they will be used, taking care to keep them off tops of ties, out of the cribs and from getting buried or lost. Material shall not be unloaded between the rails.

(e) Track materials distributed for maintenance work shall not be placed in the gage of live track.

(f) Wherever possible, CWR distributed for installation must be clear of live track tie ends. The ends of CWR strings shall be tapered away from the live track. CWR shall not be unloaded and stored in the gage of live track.

### §101.3(C) Classification

Materials are considered to be in one of the following conditions:

(a) New - Unused, as manufactured or modified.

(b) Rehabilitated - Materials removed from track upon which work has been performed since removal as:

  (1) Reformed rail anchors

  (2) Rebuilt frogs, switches and crossings

(c) Fit - Usable (second-hand), as removed from track with no work performed upon it, as fit rail (relay rail).

(d) Scrap.

### §102.0(C) Sub-ballast

(a) Sub-ballast will be considered as fill and will not reduce the amount of ballast needed for the track structure. See Standard Track Plan AM 70003.

(b) Sub-ballast materials and the furnishing and compaction of sub-ballast shall comply to latest specifications provided by the office of the Deputy Chief Engineer- Track

## §103.0(C) Ballast

### §103.1(C) General

(a) Unless it is otherwise structurally supported, all track must be supported by material that will:

(1) Transmit and distribute the load of the track and railroad rolling equipment to the subgrade

(2) Provide restraint for the track in lateral, longitudinal and vertical directions

(3) Provide drainage for the track structure

(4) Facilitate maintenance of track crosslevel, surface, and alignment

(b) Ballast shall conform to Engineering Specification Nos. 200 and 201 and may be obtained only from approved quarries.

(c) Crushed stone shall be used for ballast, except that ballast other than stone ballast, may be used at locations specifically approved by the Deputy Chief Engineer- Track.

(d) The class and size of ballast to be used for the various lines and tracks shall be determined by the Deputy Chief Engineer-Track.

(e) When ballast received is of inferior quality, has improper grading, or contains quantities of screenings, dirt or foreign matter, a report shall be made to the Division Engineer so that corrective action may be taken.

(f) If ballast is shipped under weight agreement, the Division Engineer should arrange for periodic checks of weight to protect against shortages or overloading of cars.

### §103.2(C) Distribution

(a) To the extent practicable, ballast should be unloaded in position for use with a minimum of redistribution and dressing, using special ballast cars when available.

(b) Ballast must be distributed or immediately dressed so that ample clearance below top of rail is provided for rolling equipment, switches are not fouled, and guard rails are unobstructed.

(c) Immediately remove ballast from bridge walkways, station platforms, grade crossings, and any part of turnouts that interferes with their use. When unloading on under-grade bridges take necessary precautions to protect any highways, pedestrian paths or other public access below from falling ballast and debris.

(d) Ballast level must be watched carefully in all cars and not allowed at any time to drop more than 4' below the ballast level on the other side of car. See Engineering Practice No. 202.

### §103.3(C) Cross Section

Ballast and sub-ballast cross sections should conform to Standard Track Plan AM 70003.

| | |
|---|---|
| Jointed Rail 6" shoulder | 2:1 slope |
| CWR 12" shoulder | 2:1 slope |

### §103.5(C) Size and Gradation

(a) AREMA No. 3 or 4A are the standard specifications of crushed stone used for ballast per Engineering Specification No. 200.

(b) In areas such as tunnels, where there is restricted clearance for lining and surfacing track, AREMA No. 4 ballast per Engineering Specification No. 200 may be used only with the approval of the Deputy Chief Engineer-Track.

(c) In areas where good footing is required as approved by the Deputy Chief Engineer-Track, AREMA No. 5 ballast may be used per Engineering Specification No. 201. Because of its size, AREMA No. 5 ballast is not allowed to be used on main line tracks and in restricted tunnel clearance areas.

(d) Ballast sizing is shown in the table below:

| AREMA reference | Nominal Size | Amtrak Reference | Area of Use |
|---|---|---|---|
| AREMA No. 3 | 2” to 1” | Engineering Specification 200 | Standard for Mainlines |
| AREMA No. 4A | 2” to 3/4” | Engineering Specification 200 | Standard for Mainlines |
| AREMA No. 4 | 1-1/2” to 3/4” | Engineering Specification 200 | Restricted Clearance Areas |
| AREMA No 5 | 1" to 3/8" | Engineering Specification 201 | Other than Mainlines where good footing is required |

**§103.6(C) Ballast; Disturbed Track**

If track is raised or otherwise disturbed, the track must be inspected for compliance with Amtrak Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR.

**§109.0(C) Crossties**

**§109.1(C) Specification**

(a) Wood crossties shall be in accordance with Engineering Specification No. 1907 for Purchase of Wood Crossties & Switch Ties.

(b) Concrete crossties shall be in accordance with Engineering Specification No. 10 for Concrete Crosstie and Fastening Assembly.

**§109.2(C) Use**

(a) For main tracks crossties of a depth of 7” shall be used.

(b) The Deputy Chief Engineer-Track shall determine the types and sizes of crossties to be used in any specific situation.

(c) The number of ties that shall be considered as standard for each line and class of track shall be designated by the Deputy Chief Engineer-Track, in accordance with the service requirements, based on the following spacing from center to center:

| | |
|---|---|
| All tracks - concrete | 24" |
| Main tracks - wood | 19-1/2" |
| Other tracks - wood | 24" |

(d) In third rail territory, power rail supports are spaced at every fifth wood tie and every fourth concrete tie. Ties are to be a minimum of 9'-6" in length.

**§109.3(C) Installation**

(a) Wood Crossties

(1) Ties should be placed in track with the wider heart wood face down and square to the line of the rail.

(2) The ends of standard 8'-6" ties should be brought to a uniform line 18-1/2" from the edge of the base of rail on the line side as follows:

i. On single-track roads, and in tracks of unassigned direction, line the right hand ends of ties going north or west.

ii. On roads with two or more main tracks, line the right hand ends of ties going in the assigned direction of traffic.

iii. Exceptions may be made where, in the use of tie installation machinery, it is advisable to line the opposite ends or where it is desired to retain an existing line side.

iv. When necessary to use shorter than standard length ties, they shall be centered in the track.

(b) Concrete Crossties

(1) Specialized lifting equipment is needed to install concrete ties.

(2) Intermixing wood crossties and concrete ties shall not be done during new construction.

(c) All Crossties

(1) Ties shall be kept sufficiently spaced and square to the line of rail to permit proper tamping.

(2) Crossties shall be properly tamped in the area under the rails to avoid center bounding ties.

(3) In third rail territory, the distance between third rail bracket ties will govern intermediate tie spacing. Power rail supports are spaced at every fifth wood tie and every fourth concrete tie, unless otherwise approved by Deputy Chief Engineer-Track.

**§109.4(C) Damage to Ties**

(a) All Crossties:

(1) When handling or spacing ties, care shall be taken not to damage them with picks or spiking hammers. Tie tongs, lining bars, other suitable tools or tie spacing equipment shall be used.

(2) For additional information on fastener application, see §127.0(M).

(b) Wood Crossties:

(1) When performing track maintenance, treating fewer than three adzed ties is impractical. When performing production work, all adzed ties should be treated by an approved method.

(2) Only sufficient adzing to obtain a sound and true bearing for the tie plate shall be done.

(3) Standard tie plugs, or other means approved by the Deputy Chief Engineer-Track, must be used to fill holes when spikes or lags have been drawn.

(c) Concrete Crossties:

(1) Concrete ties are easily damaged by mishandling. They must only be handled with equipment or tools intended for the purpose. Care must be exercised to ensure that they are not dropped. Sledges or spike mauls must not be used to align concrete ties. Lining bars may be used to align them provided the concrete ties are not struck with the bars.

(2) Concrete ties must be properly supported in the area under the rails before equipment is permitted to operate over them.

(3) Care must be exercised to avoid striking concrete ties when applying or removing elastic fasteners.

(4) Holes may not be drilled in or attachments made to concrete ties unless approved by the Deputy Chief Engineer-Track.

**§109.6(C) Bridge Timber**

(a) Oak ties shall be used on all open deck bridges.

(b) Bridge ties shall be adzed, framed and sized according to framing plans prior to treatment. Suitable holes must be bored for drive spikes that fasten tie spacing bars on timbers. Where ties are bored or adzed in the field, they shall be treated in an approved method.

(c) For typical installation data see Standard Track Plan AM 79401. The size of bridge ties shall be in accordance with Engineering Practice No. 1902.

**§113.0(C) Rail**

**§113.1(C) General**

As used in these instructions, jointed rails are conventional rails bolted together. CWR is rails fabricated into strings longer than 400' by butt welding and designated by the initials "CWR".

**§113.2(C) Classifications and Identification By Mill Inspection - New Rails**

(a) Rails are classified and identified in accordance with AREMA "Specifications For Steel Rails Chapter 4-2", as follows:

(b) High-strength rails shall be marked by either a metal plate permanently attached to the neutral axis, hot stamped, or in the brand that gives the manufacturer, type and/or method of treatment. Standard carbon rail shall be paint-marked blue. Heat treated rail shall be paint-marked orange. Head hardened rail shall be paint- marked orange and white.

(c) Rails except for those 80' or 39' shall be paint-marked green.

(d) Individual rails shall be paint-marked only one color according to the order listed above or as agreed upon by purchaser and manufacturer.

(e) Paint marking will appear on the top of the head at one end only, at least 3' from the end.

(f) All short length rails produced shall have the length identified in a manner acceptable to Amtrak and the manufacturer on the top of the head approximately 1' from each end.

### §113.3(C) Service Assignments - New Rails

| Class of Rail* | Use |
|---|---|
| No. 1 Rail | In all tracks except in turnouts and special trackwork. See Engineering Practice No. 1605. |
| Head-Hardened Rail or Fully Heat-Treated Rail | For turnouts, special trackwork and curve track. See Engineering Practice No. 1605. |

* No. 1 Rail - prime rail that conforms to latest AREMA specifications.

* Head-Hardened Rail - prime rail that is fully quenched and tempered in the head area only to increase hardness and strength. Head-hardened rail rolled by PST (Bethlehem Steel Company) will be marked "HH" to the right of the heat number. Head-hardened rail rolled by Rocky Mountain Steel Mill (CF&I Company) will be marked "DH" to the right of the heat number.

* Fully Heat-Treated Rail - prime rail that is fully quenched and tempered to increase hardness and strength. Fully heat-treated rail rolled by PST (Bethlehem Steel Company) will be marked "FT" to the right of the heat number.

* Head-hardened and fully heat-treated rail markings furnished by any other manufacturers shall be identified by the Deputy Chief Engineer-Track.

### §113.4(C) Service Assignment - Cropped or Fit Rails

(a) Rails in main track may be relayed or fabricated into CWR strings without restriction.

(b) Rails removed from track having only end defects, such as bolt hole cracks or head-web separations within joint bar areas, may be used without restrictions after defects have been eliminated by cropping.

(c) Fit rail for relaying should be graded and marked according to its physical condition and classified for reuse in accordance with §113.6(C).

### §113.5(C) Disposition and Shipment

(a) Rails released from renewals and retirements must be disposed of as authorized by the Deputy Chief Engineer- Track.

(b) All rail anchors must be removed from rails before loading rails into cars.

(c) For shipment, rails of any weight or classification may be loaded head up in the same car with wood stripping between layers, (except that medium manganese rail must be loaded separately and identified).

(d) Rails shipped for direct reuse must be loaded head up in cars with wood strips between layers and must be examined by the Supervisor-Track to ensure that the rails are suitable for the reuse intended.

### §113.6(C) Grading and Marking Rail for Reuse

(a) The suitability of rail for reuse will be determined on the basis of physical condition by designated inspectors.

(b) Rails containing recognizable flaws or damage not eliminated by cropping will be scrapped.

(c) Plug rails will be checked for vertical wear at one location approximately 4' from the end with an approved gage. CWR will be checked for vertical wear throughout the length of rail. Rail will be marked with stripes across the head to show vertical headwear as follows:

| | |
|---|---|
| 1 Stripe | 1/32" |
| 2 Stripes | 2/32" |
| 3 Stripes | 3/32" |
| 4 Stripes | 4/32" |
| 5 Stripes | 5/32" |
| 6 Stripes | 6/32" |

(d) Fit rail to be laid for operating speeds above 90 MPH shall have no more than 1/8" vertical and 1/8" horizontal head wear on one side only (measured 5/8" below top of rail). Rails containing engine burns or any other defects shall not be reinstalled in main track.

(e) Fit rail to be laid in all other main tracks shall have no more than 3/16" vertical and horizontal head wear.

(f) Fit rail for yard and siding shall have maximum vertical head wear of 3/8" and 1/4" horizontal head wear on either side (maximum combined horizontal wear of 1/2"). Acceptable rail wear limits for maintenance-of- way facilities shall be determined by the Assistant Division Engineer or Engineer of Track. All other rail is scrap.

(g) Rail shall have been tested in accordance with EP 1811

(h) Before cropping, rail will be visually inspected for defects. Damaged rail and rail with bends, cuts or engine burns shall be rejected.

(i) No rail shall be less than 34' after cropping.

**§113.7(C) Distribution**

(a) Rails should be unloaded in position for laying.

(b) Rails should be placed parallel with the track and base down, avoiding excessive bending or damage. Care should be taken to avoid placing rails on manhole covers or close to air lines.

(c) CWR ends must be offset and blocked to allow for thermal expansion.

(d) In yards and at locations where employees must walk close to the track, rail should be placed as near to the ends of ties as possible.

**§113.8(C) Preparation and Care**

(a) Track should be placed in good line and surface prior to rail renewals. Track to be laid with CWR must have standard ballast section for welded rail. Programmed tie renewals should be completed in advance of rail laying.

(b) Rails should be examined for defects prior to laying in track.

(c) At the time of installation, care should be taken so that no damage to rail or fastenings will result. Loose ties should be tamped to a full bearing under the rail immediately behind rail laying operations.

**§113.9(C) Laying Jointed Rails**

(a) Jointed rails should be laid, one at a time, with space allowance for expansion being provided between rail ends in accordance with the following tables:

**33' Rails**

| Rail Temperature (°F) | Rail End Space (inches) |
|---|---|
| Below -10 | 5/16 |
| -10 to 14 | 1/4 |
| 15 to 34 | 3/16 |
| 35 to 59 | 1/8 |
| 60 to 85 | 1/16 |
| Over 85 | None |

**39' Rails**

| Rail Temperature (°F) | Rail End Space (inches) |
|---|---|
| Below 6 | 5/16 |
| 6 to 25 | 1/4 |
| 26 to 45 | 3/16 |
| 46 to 65 | 1/8 |
| 66 to 85 | 1/16 |
| Over 85 | None |

**81' Rails**

| Rail Temperature (°F) | Rail End Space (inches) |
|---|---|
| Below 35 | 5/16 |
| 35 to 47 | 1/4 |
| 48 to 60 | 3/16 |
| 61 to 73 | 1/8 |
| 74 to 85 | 1/16 |
| Over 85 | None |

**Greater Than 81' and Less Than 400' Rails**

Rails greater than 81' and less than 400' must be temperature adjusted and anchored in accordance with Amtrak Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR.

(b) To ensure the required space allowance, rail ends should be brought squarely together against approved expansion shims of proper thickness and the rail joints bolted before spiking.

(c) Space between rail ends in insulating joints should only be sufficient to permit insertion of standard end posts.

(d) A standard rail thermometer shall be used in accordance with Amtrak Procedures Manual for the installation, adjustment, maintenance, and inspection of CWR. The supervisor in charge shall see that rail temperature is checked frequently and that proper rail expansion shims are used.

(e) The preferred joint location to prevent the possibility of short warp follows. Whenever possible, rails should be laid so that the joints of one line of rails are opposite the half point of rails in the other line with permissible variations as follows:

(1) When possible, the staggering of joints on one side should not vary more than 18" in either direction from the half point of the opposite rail.

(2) Where approved by the Deputy Chief Engineer- Track, and protected by a 30 MPH speed restriction, joints on tangents in newly constructed track laid by the panel method, other than main track, may be left equal and opposite. When possible, joints on curves should be staggered in accordance with paragraph (1) above.

(f) It is the goal of the Engineering Department to have no jointed rails in track less than 39' in length. Under certain conditions shorter rails may be required.

(g) Rails less than 18' in length should not be used in main tracks. In some situations, it may not be possible to install an 18' rail. Under the following conditions rails with a minimum length of 14' may be used for:

(1) Connections within turnouts and crossovers

(2) Temporary closures

(3) Temporary replacement of broken rails

(h) Existing short rails greater than 14' in length need not be removed until the rails are changed or re-laid.

(i) If possible, when laying rail, avoid placing bolted joints in or closer than 120' to the edges of road crossings, or closer than 20' within the limits of switch rails, guard rails, ends of open floor bridges, concrete deck track, trestles or viaducts.

(j) Rails of the same section should be used on open floor structures, through road crossings and paved track areas of station platforms, and to the greatest extent possible in turnouts and crossovers.

(k) Rails of unequal wear and different sections must be brought to an even surface at joints.

**§113.10(C) Bolt Holes**

Holes must be provided in accordance with standard plans and the following practice:

(a) When holes are necessary, they must be drilled. Bolt holes should be drilled with the joint bars removed or before their application, either by marking the location of the center of the hole, preferably with a proper size template block and center punch (if applicable) and placing the cutting tool directly against the web of the rail or by drilling through an approved template.

(b) When bolt holes are drilled, a uniform feeding pressure should be maintained and then reduced as the cutting tool cuts through the opposite side of the web. Forcing the cutting tool may produce a ragged hole, with the possibility of bolt hole cracks. Lubricant should be used throughout this operation.

(c) After drilling is completed, bolt holes should be brushed out and inspected. Any burrs or chipped edges should be removed by grinding or filing to a smooth edge around the entire circumference of the hole.

(d) The minimum distance from the end of a rail to the center of the first bolt hole must not be less than twice the diameter of the hole, except where the standard plan for that rail provides for a shorter distance.

(e) The distance between the centers of any two holes of the same diameter must not be less than 4 times the diameter of the holes, and in the case of holes of different diameters not less than 3-3/4 times the average diameter of the two holes.

(f) The connection between rail ends should be made with fully bolted joint bars.

(g) When it is necessary to use a cut rail at a compromise or insulated joint location, the mill or shop-drilled end of the rail should be placed in the compromise or insulated joint. The bolt holes must be accurately drilled in accordance with provisions of paragraph (a).

(h) When connecting CWR or cutting in a replacement rail, only the second and third holes shall be drilled for field welding.

**§113.11(C) Cutting Rail**

(a) The tools that may be used for cutting rails are listed below:
  (1) Power saws with approved guide attachments
  (2) Gas cutting torches, only in an emergency in accordance with §213.122.

(b) Gas or electric arc welding is prohibited on any portion of the rail, except as listed below:
  (1) Application of welded bonds
  (2) Top of rail within limits of joint bars

(c) Any rail damaged by torches must be promptly removed from track.

**§113.12(C) Rails Bonded for Track Circuits**

(a) Where rails are bonded for track circuits, no rail bonds shall be broken or rails removed, except in case of an emergency, unless a signal maintainer is present and material to bond the new rail is available.

In case of an emergency, a broken rail, or switch or frog may be renewed without waiting for the signal maintainer. In such cases, the joints shall be tightened to make a positive contact and the signal maintainer notified that the rail bonds have been broken. However, if such work is within the starting circuit of automatic highway crossing protection, the track shall not be restored to service until all trains approaching the crossing have been instructed to be prepared to stop prior to passing over the crossing, until crossing protection is restored.

(b) In electric traction territory, care shall be exercised to ensure that at least one return path for electric traction current is maintained, before disconnecting leads of impedance bonds or removing rails, frogs, etc. When making rail renewals, before the rail is disconnected, a return path for current shall be provided by using a temporary bond across the track each side of the section of rail to be removed, making sure that no insulating rail joints interfere with this cross bonding circuit. In emergencies, when the signal maintainer is not present, notifications that the rail bonds have been broken will be made.

(c) Care should be taken to avoid shunting of track circuits with tools, jacks, lining bars, claw bars, tapes or other material carried or laid across the rails.

### §115.0(C) Rail End Mismatch

Rail shall be maintained so that the mismatch of rails at joints may not be more than that prescribed in the following table:

| Rail End Mismatch Construction Limits | | |
|---|---|---|
| **Any mismatch of rails at joints may not be more than the following:** | | |
| **Class of Track** | **On the head of the rail ends (inch)** | **On the gage side of the rail ends (inch)** |
| **1-3** | 3/32 | 3/32 |
| **4 and 5** | 1/16 | 1/16 |
| **6-9** | 3/64 | 3/64 |

### §118.0(C) Rail Lubrication

(a) The gage face of all new rail or new trackwork installations that fall under the following categories must be lubricated.

(1) Running rail in curves greater than 6°

(2) All switch points and stock rails regardless of turnout size or type

(3) All frogs through the turnout side only, except No. 26-1/2" and 32-3/4" frogs

(4) Curved turnout or closure rails (both running rails) for No. 15 and smaller size turnouts.

(a) Lubrication may include either the outside or inside rail, or both, if both have been renewed. Lubrication will be applied to the renewed steel and approximately 20' beyond in each direction. This lubrication will be reapplied on an every other day cycle for a minimum of 30 days of traffic.

(b) Standard curve lubrication grease such as Rykon Premium Grease No. 1487 or its approved equivalent will be used. It will be applied to the gage face only by liberal brush coat.

### §119.0(C) Continuous Welded Rail

(a) It is important to maintain the desired neutral temperature of CWR so that the track remains stable.

(b) When performing work it is important to recognize activities that do not change the neutral temperature of CWR or significantly change the neutral temperature of CWR.

(c) All construction work regarding CWR must be done in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR

### §119.1(C) Use

(a) CWR fabricated by an approved process may be laid without restriction in fully ballasted tracks.

(b) CWR may be laid across open deck bridges where bridge ties are spaced with timber blocks between ties, provided that the following conditions are satisfied:

(1) All ties and blocks are tightly jacked and fastened together with spacing bars secured by lag screws in at least every third tie.

(2) Bridge ties are securely fastened to the steel structure by means of hook bolts, tie anchors or other approved holding devices.

(3) The bridge structure is properly anchored to abutments and piers to prevent any movement other than normal expansion.

(4) CWR is anchored to the bridge ties in both directions in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR).

(5) Approved elastic fastening systems shall be used on the running rails of all new bridge timber installations.

(c) After application, approved holding devices must be checked and retightened weekly until ties have fully seated on top flanges of built-up members.

**§119.2(C) Welding or Bolting CWR**

(a) CWR strings may be field butt welded by an approved method in all track classes. When it is necessary to temporarily connect CWR strings, the rail should be at least 14' long.

(b) If it becomes necessary to apply temporary joint bars, the end bolt hole in each rail must not be drilled as this would prevent subsequent field welding. Additional rail anchors must be applied to this joint in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

(c) When it is not intended to field weld, CWR strings are to be fastened to each other or to other rails with fully bolted rail joints.

(d) Thermite welding shall not be performed within the limits of a highway grade crossing.

(e) Only a power saw may be used to cut rails for thermite welding.

**§119.3(C) Rail Anchoring**

Each CWR string is to be anchored in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR).

**§120.0(C) Field Welding**

(a) The goal of the Engineering Department is to reduce the quantity of joints in track by laying CWR and field welding joints wherever possible.

(b) Thermite and flash butt are acceptable methods for in track field welding.

(c) Thermite welding shall be performed in accordance with Engineering Practice No. 2003.

(d) All new turnouts and special trackwork shall be field welded to include frogs, switch points and stock rails.

(e) If it becomes necessary to apply temporary joint bars, the end bolt hole in each rail must not be drilled as this would prevent subsequent field welding. Additional rail anchors must be applied to this joint in accordance with §125.1(C).

(f) Thermite welding shall not be performed within the limits of a highway grade crossing.

(g) Field welding on open deck bridges is permitted in accordance with Engineering Practice No, 2003. provided all the following conditions are met:

(h) A qualified individual using a 17-pound dry chemical ABC extinguisher is available to protect against fires.

(i) A qualified individual must be present for a period of at least two hours after the last field weld is finished and ground.

(j) An extra 17-pound ABC extinguisher must also be readily accessible as a backup.

(k) While extinguishing any fires, the qualified individual must stand upwind and aim the chemical at the base of the fire.

(l) A qualified B&B representative must be present during the entire welding operation from beginning of welding process to at least one hour after the last field weld is finished and ground.

(m) Flash butt welding, shearing and grinding shall only be performed when there is no highway or river traffic directly under the area of the welding.

(n) Bridge timber spacing may be more restrictive than that of ballasted track. Welding shall not be performed if the tie crib is less than 5-1/2" in width.

(o) Welds on open deck bridges must be made as close to the center of the crib as possible. The minimum distance between center of weld and edge of tie shall be 2-3/4".

(p) After welding, the entire structure should be inspected for possible "hot spots" or fire.

(q) Field welds shall be located as follows:

    (1) At least 14' away from a field weld or joint in the same rail.

    (2) At least 4' from a plant weld in the same rail.

    (3) At least 14' from a bonded or a bonded insulated joint.

    (4) At least 20’ away from a change in type of track construction, such as but not limited to: wood tie to concrete tie, ballasted track to open deck bridge, ballasted track to direct fixation.

(r) When the above minimum distances cannot be met, correction shall be made by installing the proper length plug rail (not less than 18'). The rail should be cut to a length that will ensure placement of the weld in the center of the crib. If not possible, the weld may be located a minimum of 2-3/4" from the nearest tie or tie plate, whichever is closer. If the above conditions cannot be met, respace the ties.

(s) In no case will a field or plant weld be made within 6" of a bolt hole.

(t) Welds in new turnouts may not conform to the above standards in all locations. However, every effort should be made to use the above standards.

**§121.0(C) Rail Joints**

(a) Rail ends shall be fastened together by bolted standard, compromise, insulated, or glued joints.

(b) The use of acetylene torches or grinding to manufacture or change the dimensions of compromise joint bars is prohibited.

(c) Compromise joint bars of an approved design shall be used to join rails of different sizes.

(d) If rail end mismatch exists after applying approved joint bars the rail head and gage face surfaces may be adjusted by welding the smaller rail and grinding to finish the weld.

(e) Each rail joint, insulated joint, and compromise joint must be of a structurally sound design and dimensions for the rail on which it is applied.

(f) If a joint bar is cracked, broken or because of wear allows excessive vertical movement of either rail when all bolts are tight, the joint bar shall be changed.

(g) In main line track construction with conventional jointed rail, each rail must be bolted with all rail holes filled.

(h) If a permanent connection is made between CWR and bolted rail, all joint bar holes must be filled.

(i) Each joint bar must be held in position by track bolts tightened sufficiently to provide firm support for abutting rail ends and to allow longitudinal movement of rails in the joint to accommodate expansion and contraction due to temperature variations.

(j) In CWR, joints shall be tightened as much as possible, without regard for longitudinal expansion.

(k) No rail or joint bar having a torch cut or burned bolt hole may be used in track. When new holes are necessary, they must be drilled. Punching, slotting or burning with a torch is prohibited.

(l) No joint bar shall be reconfigured by torch cutting.

(m) When laying track panels or cutting plugs into CWR, joints and/or welds shall be staggered on opposite rails to avoid joints and/or welds located in the same crib.

**§121.1(C) Bolted Rail Joints**

(a) General

- (1) Bolted rail joints consist of either head free, or head contact standard bars and head contact compromise joint bars held in position by track bolts.
- (2) Head free bars must have the inner surface of the head of the bar held tightly against the rail head fillet with the heel of the bar standing out from the base fillet. See Standard Track Plan AM 71381 for an example of head free joint bars.
- (3) Head contact bars must have the top surface of the bar held tightly against the fishing surface under the rail head but away from the rail head fillet area. Bars must be secured in a vertical position to avoid cocking. See Standard Track Plan AM 71160 for an example of head contact joint bars.

(b) Application

- (1) Joint bars shall be applied in accordance with standard plans and specifications.
- (2) New bolts, nuts and spring washers should be used when new or fit joint bars are applied.

(c) Head free joints

The following procedure should be followed in applying head free joint bars:

- (1) Set bars in position, insert all bolts and apply spring washers and nuts by hand.
- (2) Tighten up center two nuts without over tightening to avoid locking the bars in an improper position. Strike the bead on the head of both inside and outside bars at both ends with a sledgehammer to force the inside faces of bars tightly against rail head fillets. Do not strike the toe of the bar as this tends to force the head of the bar outward.

(3) Tighten all bolts, working from the center of joint bars outward. During this final tightening, drive the toes of the bars inward by tapping with a sledgehammer.

By following the above procedure, proper contact will be obtained between the inner face of head of bar and the rail head fillet. Also, the heel of the bar will stand out the proper distance from the rail base fillet.

(d) Head contact joints

The following procedure should be followed in applying head contact joint bars:

(1) Set bars in position on rail, insert all the bolts and apply spring washers and nuts by hand.

(2) See that bars are in a vertical position while tightening the center bolts.

(3) Tighten all bolts working from center of joint bars toward ends, tapping the toe of joint bars with a sledge so that their vertical position is maintained.

**§121.2(C) Insulating Rail Joints**

(a) For new work or rail renewals in track circuit territory, insulating joints shall be located as follows:

(1) Where track circuits adjoin within limits of interlockings, in cab signal territory, electrified territory or in territory where stray current is likely to be prevalent, insulating joints shall be staggered not more than 56" nor less than 24".

(2) To provide for effective electric locking, insulating joints, staggered as prescribed in paragraph (1) above, shall be located with respect to signals as follows:

i. No insulating joint shall be placed less than 5' nor more than 13' in advance of a high signal, except that where there are opposing high signals at the same location, the insulating joints shall be placed as near an equal distance (between) opposing high signal as practicable.

ii. Insulating joints shall be placed as nearly opposite dwarf signals as practicable.

(3) At locations other than those listed above, insulating joints may be staggered not more than 10'.

(4) Insulating rail joints need not be specially staggered at the end of a track circuit where there is no adjoining track circuit or fixed signal.

(5) Insulating rail joints in turnouts and crossovers, and at highway grade crossings, shall be located in accordance with the applicable Track and C&S Standard Plans.

(b) Continuous insulating joints (Block Joints) shall not be used in new construction.

(c) Application of bonded insulating joints (Glued Insulated Joints)

(1) Bonded insulated joints are required on all concrete tie tracks and should be used in all CWR, in accordance with Standard Track Plans AM 71374 and AM 71375.

(2) Conventional rail joints adjacent to bonded insulating joint rails must be field welded.

(3) All bonded insulating joints are to be installed as suspended joints.

(4) Double shoulder tie plates must be used on the two wood crossties supporting suspended bonded insulating joints.

(5) Rail holding spike heads must be in reverse position and must be carefully driven to ensure that spike head is not in contact with the bar, which could result in the joint's being short circuited. All bonded insulating joints will have plate holding spikes installed. An approved type of fastener shall be used where insulated joints are installed in concrete crosstie track.

(6) Joints installed with resilient fasteners shall have the correct clips (modified "e"

clip) applied to prevent possible damage to the joint.

(7) No attempt should be made to tighten bolts in bonded insulated joints. In the event the bolts in the joint become loose, the joint should be replaced.

(8) Any rail head overflow at a bonded insulating joint is to be removed by grinding. Extreme care must be exercised to ensure that the end post is not damaged. The overflow should be ground only to the rail end, so that the joint gap will not be greater than the original 3/16". A cross grinder/slotter should not be used to remove the overflow.

(9) The bonded insulating joints will be considered as welded rail joints for purposes of compliance with the anchoring requirements of §125.1(C).

(d) Care of joints: Insulating joints should be installed on effective crossties, tamped and with proper ballast section.

(e) Application of Polyurethane-Coated Steel Insulated Joints

(1) Bonded insulated joint plugs are the preferred Amtrak standard.

(2) Polyurethane-coated steel insulated joints may be used in yards, sidings, curved leads in industrial sidings from the main track and interlockings where CWR has not been installed.

(3) Polyurethane-coated steel insulated joints may be used permanently on main lines with Track Classes 1-3 speeds where the use of a bonded insulated plug rail is not practical.

(4) In no case will a polyurethane-coated steel insulated joint be installed in tracks where the track speed is Track Class 4 and above except as a temporary repair. These temporary joints must be removed within seven days of installation.

(5) Polyurethane-coated steel insulated joints are to be installed as suspended joints.

(6) The top of the polyurethane-coated steel must be set first into the fillet area of the rail, torquing the bolts from the center to the ends.

(7) Reverse rail holding spikes and do not drive up against the polyurethane-coated steel.

(8) A bolt should never be driven through an insulated bushing, as it will destroy the bushing. If rails and joint parts are in correct relative position and the bolt holes lined up, the bolts can easily be inserted by hand.

**§123.0(C) Tie Plates**

**§123.1(C) Use**

(a) Tie plates shall be installed under running rails on all wood crossties, switch ties and bridge ties.

(b) Only double shoulder tie plates should be used under CWR.

**§123.2(C) Placement**

(a) Canted tie plates shall be installed so that the rail cants towards the centerline of track.

(b) Tie plates must be placed square to the base of the rail and no portion or part of the shoulder can be under the base of the rail.

(c) No metal object that causes a concentrated load by solely supporting a rail shall be allowed between the base of the rail and the bearing surface of the tie plate. Examples include tie plate shoulders, spikes, etc.

### §123.3(C) Tie Pads

(a) The use of tie pads, to include open deck bridges, may be used only with the approval of the Deputy Chief Engineer-Track.

(b) Elastomeric tie pads must be used on concrete ties. There are several designs, such as those used with the "PR601A," "e" clip and "fast" clip assemblies. See the applicable Standard Track Plans.

### §125.0(C) Rail Anchors

Each CWR string is to be anchored in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

### §125.1(C) Number Required

(a) A sufficient number of anchors must be applied and, in a manner, to effectively control longitudinal rail movement, as required by §213.125.

(b) Insufficient anchors may result in improper distribution of expansion allowance, or stresses in rail, and consequent distortion of line and surface, which can create a hazardous condition.

(c) It should be recognized that when track is raised out-of-face, the resistance to creepage is reduced and additional anchors may be required in order to avoid undue movement.

(d) When constructing track, every other wood tie shall be fully box anchored.

(e) A fully clipped wood tie, bridge timber, and fully clipped and insulated concrete tie is considered equivalent to a box anchored tie.

### §125.2(C) Application

Rail anchors shall be applied as follows:

(a) Anchors shall be applied at both ends and on the same side of the tie. They should be spaced evenly throughout the rail length. Where special applications may be necessary, other spacing may be used with permission of the Deputy Chief Engineer-Track. Wherever practicable, rail anchors shall be applied from the gage side of the rail.

(b) When laying rail, the necessary anchors shall be applied immediately after rail is adjusted and before trains are permitted to pass over the track.

(c) Anchors should be applied against sound ties.

(d) When anchoring track, regardless of the type and direction of traffic, ties should be box anchored wherever possible.

(e) When ties at a joint cannot be anchored because of interference with a joint bar, no anchors shall be applied to the affected ties.

(f) Drive on type anchors shall be applied to switch stock rails, applied from the field side of the track. Care must be taken in application of anchors so as not to foul switch rods.

### §125.4(C) Assignment

The use of rail anchors should be in accordance with the following service assignment:

(a) Use new or reformed anchors in laying:

    (1) New bolted or continuous welded rail

    (2) Continuous welded fit rail

### §127.0(C) Track Fasteners

### §127.2(C) Application

(a) All elastic fasteners shall be inserted into or removed from the cast-in-place shoulder (concrete tie) or tie plate (wood tie) with an approved device such as a "pan- puller" or sledgehammer. The use of a spike maul is prohibited.

(b) Elastic fasteners should not be overdriven as overdriving will cause premature relaxation of the fastener. Fasteners that have been overdriven or are not performing their intended function of limiting the vertical and longitudinal movement of the rail shall be replaced.

(c) In the case of the "e" clip, a distance of 3/8" (approximate width of a wooden pencil) between the shoulder and the face of the clip is required to prevent overdriving.

(d) In the case of the "fast" clip, the clip shall be driven or inserted until the clip is engaged in the shoulder notch.

(e) When applying "e" or the "PR 601A" clips with a sledgehammer, the clip must initially be gently tapped to ensure proper insertion before the clip is fully seated. When removing "e" or "PR 601A" clips with a sledgehammer, the clips must initially be gently tapped to remove the toe load to ensure safe removal of the clips.

(f) When inserting clips by either the sledgehammer or pan- puller methods, the tie must be flush with the bottom of the rail or assistance will be required to raise the tie so the pan-setter may be used for clip application.

(g) Care must be exercised so as not to strike the concrete tie or concrete tie shoulder in order to prevent damage to the tie. Striking a concrete tie to make adjustments in the alignment of the tie with any type of device is prohibited.

(h) 15/16" diameter coach screws shall be used to secure cold rolled plates (1" diameter holes) with elastic fasteners to wood ties and timber. Coach screws must be screwed into a 11/16" diameter pre-drilled hole, 6" deep. Driving of coach screws with a sledgehammer or spike maul is prohibited.

(i) All spikes shall be driven with the head pointed toward the rail, except spikes against sides of all joints, and bonded and polyurethane-coated steel insulated joints shall be driven with the head pointing away from the rail and not in solid contact with the joint bars.

(j) Spikes should not be driven at ends of insulated joints in any manner that would cause the insulated joint bar to become electrically connected to the rail.

(k) Spikes must be started vertically and square and driven straight. The shank of rail holding spikes must have full bearing against the base of rail. Spikes should be driven in accordance with Standard Track Plan AM 72051 being careful not to overdrive. The use of lock spikes (hair pins) is prohibited.

(l) Care must be taken not to strike the rail, its fastenings or signal appliances when driving spikes.

(m) Throat cut, rusted, deteriorated or bent spikes are not to be used for construction.

(n) Any spikes that are pulled shall be picked up, sorted and returned for reuse, if applicable, or scrapped.

(o) Track spikes (cut spikes) shall not be driven into round plate holes.

(p) On all open deck bridge structures, when the head of the track spike is broken off, the replacement spike should be inserted in a new location, leaving the spike stub in the tie. If a new spike location is not available, the stub shall be driven completely through the tie to avoid shunting the track circuit.

(q) All old spike holes shall be plugged with treated or cedar wood plugs prior to re-spiking.

### §127.3(C) Rail Fastening Systems

(a) Track shall be fastened by a system of components that effectively maintains gage within the limits prescribed in §213.53. Each component of each such system shall be evaluated to determine whether gage is effectively being maintained.

(b) When spikes and elastic fasteners are used, unless otherwise ordered by the Deputy Chief Engineer-Track, each rail shall be fastened to every tie in the following manner:

| Track | Rail holding spikes (1) | Plate holding spikes or lag screws (1) |
|---|---|---|
| ***Conventional Tie Plates*** | | |
| Tangent and curves under 1° | 2 | 1 |
| Curves 1° and over and trackwork except for curved closure rail | 2 | 2 |
| Curved closure rail of trackwork | 3 (1 field side; 2 gage side) | 1 (field side) |
| ***Elastic Fastener Plates*** | | |
| Tangent and curves under 1° | 2 Elastic Fasteners | 3 (2 field side; 1 gage side) |
| Curves 1° and over and trackwork | 2 Elastic Fasteners | 4 |

(1) Lock spikes (hairpins) are not to be used.

(c) The application of spikes shall be in accordance with §127.2(C) and Standard Track Plan AM 72051. Lock spikes are not to be used.

(d) Each concrete crosstie must have four resilient fasteners, four insulators and two tie pads in accordance with the Standard Track Plans.

(e) Each wood tie with a resilient fastener system must have four elastic fasteners and meet the requirements of §213.127.

### §145.0(C) Inner Bridge Guard Rails

### §145.1(C) General

(a) Inner bridge guard rails must be properly installed and maintained. Installation shall be in accordance with Standard Track Plan AM 71791 and applicable plans for wood and concrete ties.

(b) A "single" guard rail is a continuous line of rails fastened to ties adjacent to the gage side of one running rail. A "full" guard rail consists of two such lines of rail, one adjacent to the gage side of each running rail.

### §145.2(C) Use

(a) Inner bridge guard rails shall be used on:

    (1) Through truss bridges, moveable bridges, and structures supported on piers or on bents that may be struck by derailed equipment that could result in possible failure of the structure.

    (2) With bridges that have piers or bents with considerable skew or that extend beyond the bridge trusses due to the angular crossing of a road, railroad or

waterway.

(b) Guard rail arrangement shall be as follows:
   (1) Single track — Full guard rail.
   (2) Double track — Single guard rail in each track to deflect derailed wheels away from adjacent truss.
   (3) Three or more tracks — Single guard rails in each outside track to deflect derailed wheels away from adjacent truss. No guard rail is to be placed on other tracks.
   (4) Movable bridges — Full guard rail in each track except through locations of miter rails.
   (5) On other structures as may be designated by the Deputy Chief Engineer-Track.

**§145.3(C) Material**

(a) Scrap or fit rail will be used. The rail section, when installed, will be equal to or not less than 2" below the top of the running rail.

(b) Joints may be either four- or six-hole bars with a minimum of four bolts, without washers, per joint.

(c) On timber ties, no tie plates or braces will be used with inner bridge guard rails. Concrete ties require special tie plates.

**§145.4(C) Application**

(a) Inner guard rails shall extend to a sufficient distance (approximately 30'-40') beyond the bridge backwalls. Guard rails shall be parallel to and 11" from the gage of running rails to the guard face of the guard rail throughout the entire length of the structure to be protected.

(b) On concrete ties the distance from the gage face of the running rail to the guard face of the guard rail will be greater than 11" and will depend upon the type of concrete ties used.

(c) Full guard rails shall end on a tie in the middle of the track, with the ends beveled or bent down in accordance with Standard Track Plan AM 71791 for wood ties and approved plans for concrete ties so as to contain a derailed wheel and not catch dragging equipment.

(d) Single guard rails shall end on a tie, approximately 12" (wood ties) from the gage of the opposite running rail and beveled or bent down so as to avoid catching dragging equipment. The distance to the opposite running rail will vary for concrete ties based on the shape of the concrete tie and guard rail plate location.

(e) To facilitate diverting derailed wheels, the guard rail shall be lined to a smooth uniform curve and/or tangent from bridge backwall to the guard rail end.

(f) Inner guard rails must be installed to protect the structure from traffic on both directions on that track.

(g) Inner bridge guard rails will be spiked on each crosstie or bridge timber with one spike on each side of the rail or casting. Spike holes should be pre-bored and spikes offset from each other to avoid splitting timber.

National Railroad Passenger Corporation

# PART II

# LIMITS AND SPECIFICATIONS FOR TURNOUT (AND OTHER TRACKWORK) SAFETY, MAINTENANCE AND CONSTRUCTION

# MW 1000

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# SUBPART A-D

# LIMITS AND SPECIFICATIONS FOR TURNOUT AND OTHER TRACKWORK SAFETY

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**LIMITS AND SPECIFICATIONS FOR TURNOUT (AND OTHER TRACKWORK) SAFETY**
**SUBPARTS A-D**
**Track Classes 1-9**

## Table of Contents

## Subpart A(TO) — General

### §213.1.0(TO) Scope of Subpart

(a) This subpart includes the general requirements for turnouts, slips, crossings (diamonds), and other special trackwork. Miter rails and expansion joints are found in Part III.

(b) Part II provides information that is not found in other parts. The more restrictive safety, maintenance and construction limits found here supersede limits found in other parts. Any safety, maintenance or construction limits found in Part I that do not appear in Parts II and III shall apply.

(c) In the case where differences may exist between these standards and those prescribed in 49 CFR 213 (FRA Track Safety Standards), the more restrictive shall apply.

(d) Inspections of special trackwork shall be made as prescribed by §213.230(TO) and §213.235(TO). The results of these inspections shall be reported on the appropriate inspection forms. These inspections shall be made to ensure the integrity and safety of all components and systems that make up trackwork (i.e., switch machines, circuit controller, derail, switch heater, etc.).

(e) These requirements and limits apply where one of the described track conditions is found to exist at a single location. Where a combination of two or more of these conditions is found to exist at the same location, even though none are individually beyond the safety limits, judgment must be used to determine the extent to which such combinations may require remedial action to provide for safe operations over that track.

### §213.3.0(TO) Application

(a) Except as provided in paragraph (b) below, this subpart applies to all tracks maintained by Amtrak.

(b) This subpart does not apply to tracks located inside industrial installations which are not used by the railroad as part of its operating facilities.

### §213.5.0(TO) Responsibility for Compliance

(a) Primary responsibility for inspection of trackwork is delegated to the Track Department. In addition, the C&S Department plays a key role in these inspections and should participate in periodic joint inspections of trackwork with the Track Department.

(b) When it is known by track supervision, or track supervision has responsible notice that a track does not comply with the requirements of this Part, the following action must be taken:

    (1) Make initial notification (non-class-specific defects). See Part I, §213.22.

    (2) Repair or improve the track.

    (3) Reduce the operating speed to within a range for which the track does comply.

    (4) Place the track out of service.

(c) Remedial action must be taken before the passage of a train.

### §213.7.0(TO) Designation of Qualified Individuals

(a) Amtrak shall designate qualified individuals responsible for the inspection and maintenance of trackwork as prescribed in Part I, §213.7(b).

(b) Individuals making inspections of track and trackwork shall be trained by and have met the requirements of the Training Department. Individuals successfully meeting these requirements shall be qualified by the Deputy Chief Engineer-Track.

(c) The Deputy Chief Engineer-Track shall approve the training program for the inspection and maintenance of trackwork.

(d) Individuals that are responsible for constructing, inspecting, maintaining, and restoring trackwork shall be qualified on the general characteristics and nomenclature of trackwork. Inspectors shall be thoroughly familiar with the procedures, techniques, and equipment required to perform inspections in accordance with this Part.

(e) Designated inspectors and persons responsible for the sign-off and review of inspections, as prescribed in this Part, are given in §213.235.

### §213.8.0(TO) Definitions

Definitions of major systems and components of trackwork and advanced technology turnouts are provided in Appendix A to establish a standard nomenclature that shall be used throughout this Part.

### §213.8.1(TO) Drawings/Photos (General)

Schematics of trackwork are provided in MW 1000 to illustrate the placement, location, and general arrangement of major trackwork components. The major trackwork types and components are illustrated in Appendix F.

### §213.8.2(TO) Types

(a) Standard turnouts currently being used by Amtrak can be found on Amtrak's Sharepoint located here: Standard Plans

(b) See Appendix F: Table 1 for a list of Turnout Descriptions, Turnout Classifications, and Standard Track Plan numbers.

### §213.8.3(TO) Turnout Characteristics

See Appendix F for Turnout Characteristics.

### §213.8.4(TO) Slip Switch Characteristics

See Appendix F for Slip Switch Characteristics.

### §213.9.0 (TO) Diverging Speeds

(a) Inspectors are reminded that the speed of the track through the two routes of a turnout will likely be different. Track class will be determined by the speed of the route inspected.

(b) Unless restricted to a lower class designated in the timetable, the maximum authorized speeds through diverging movements on turnouts will be as followed:

| Frog No. | Maximum Authorized Speed - MPH |
|---|---|
| 32.75 | 100 |
| 26.5 | 80 |
| 24 | 60 |
| 20 | 45 |
| 15 | 30 |
| 10 | 15 |
| 9 | 15 |
| 8 | 15 |
| 6 | 5 |

(c) Exceptions to the above table, including special trackwork or frogs greater than a No. 32.75 or less than a No. 8 must have the approval of the Deputy Chief Engineer-Track.

(d) When turnouts or crossovers are located in curved tracks, speeds must be adjusted to agree with Part I, §57.0(c), 59.0(c), 63.0(c) and 213.64(TO).

(e) Maximum timetable operating speeds will be designated by the Deputy Chief Engineer-Track.

### §213.15(TO) Penalties

(a) If any requirement prescribed in this Part is violated, the railroad and its employees may be subject to a civil penalty by the FRA.

For the purpose of this section, each day a violation persists is treated as a separate offense.

## Subpart B(TO) — Safety Limits

### §213.50(TO) Required Measurements

(a) Safety limits are limits, once passed, that would require the immediate repair of track, slow orders, or removal from service. It is Amtrak's policy to have track that never reaches these limits.

(b) Each turnout inspection form has dedicated columns and rows that are provided as part of the inspection report for the inspector to make and record required measurements.

(c) Measurements shall be recorded on the appropriate inspection report and compared with the prescribed minimum acceptable safety limits contained in the applicable subparts of MW 1000.

(d) The inspector may take as many additional measurements as required to adequately describe the condition of the turnout.

(e) The inspector shall have the necessary complement of tools required to perform the appropriate level of inspection. (See §213.250 for a recommended list of tools.)

(f) Wayside turnouts will be identified by name and location as designated in the timetable.

(g) Switches within interlocking limits shall be designated by number and name of interlocking.

### §213.51(TO) Safety Limits

(a) Measurements made during turnout inspection shall be compared with the values or limits specified in this subpart or with the appropriate subparts of Part I.

(b) The inspector will take the necessary remedial action, if required, in accordance with Part I, §213.5.

### §213.53(TO) Gage

(a) Gage measurements shall be taken in trackwork as indicated on the appropriate inspection form and shall not exceed the prescribed limits given in Part I, §213.53.

(b) No. 9 solid center frog gage limitations are to be in accordance with §213.142(TO).

### §213.55(TO) Alignment

Alignment measurements shall fall within the prescribed limits given in Part I, §213.55.

### §213.57(TO) Curves, Elevation, and Speed Limitations

Elevation measurements and the maximum allowable speed in curves shall be as prescribed in Part I, §213.57.

### §213.63(TO) Surface

Track surface measurements shall fall within the prescribed limits given in Part I, §213.63.

### §213.64(TO) Turnouts Diverging to the High Side of Curve (Track Surface)

(a) Turnouts and crossovers in curves that have the diverging route (turnout side) to the outside of the curve shall:

  (1) Meet the requirements of Part I, §213.63.

  (2) Be inspected and maintained according to the maximum allowable speed for the diverging route and the straight route.

(b) When the diverging route of a turnout or crossover is located to the outside of a curve:

(1) The maximum speed through the diverging route will be determined by using the $V_{max}$ formula (Part I, §213.57) or the geometry or layout of the turnout (see §100.2 (TOC)); whichever is more restrictive.

(2) For a turnout located in a uniformly elevated curve, the reverse crosslevel elevation follows the same requirements of §213.63. The limits for §213.63 are listed below:

| **Crosslevel on Turnouts diverging to the high side of a curve** | | | | | | |
|---|---|---|---|---|---|---|
| **Class of Track of Diverging Route** | **1** | **2** | **3** | **4** | **5** | **6** |
| **The reverse crosslevel elevation on curves may not be more than** | 3” | 2” | 1-3/4” | 1-1/4” | 1” | 1/2” |

(c) Example: The crossover to Shoreline Junction on the New England Division turns out or diverges to the high side of a 1°-48' curve. The desired diverging route speed through the crossover is 10 MPH (F) and 15 MPH (P); or Class 1 speed. Determine the maximum amount of superelevation that can be put in the main line curve and the maximum operating speed on the main line curve.

For a diverging route that is Class 1 (15 MPH (P)) the maximum reverse crosslevel elevation permitted in the diverging route of the turnout may not be more than 3" (see above table). The main line/straight through curve may not be elevated more than 3". The maximum main line operating speed is (Part I, §213.57):

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

$V_{max}$ = Maximum allowable operating speed (MPH)
$E_a$ = Actual superelevation of the outside rail (inches)
$E_u$ = Underbalance (inches)
$D$ = Degree of curvature (degrees)

Refer to Appendix B for underbalance charts.

D = 1° - 48’ = 1.80°

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

$$V_{max} = \sqrt{\frac{3.0 + 3.0}{0.0007(1.80)}}$$

$$V_{max} = \sqrt{\frac{6.0}{0.00126}}$$

$$V_{max} = \sqrt{4761.90}$$

$$V_{max} = 69.00$$

$V_{max} = 69\ MPH$ (See Appendix B, page B-3)

## §213.109(TO) Switch Ties

(a) Switch ties shall be visually inspected to assess their condition and performance in the turnout.

(b) Switch ties shall meet the requirements of Part I, §213.109.

(c) Defective switch ties shall be noted by tie number (for concrete), type of tie, and tie length, on the inspection report.

(d) In addition to the inspection guidelines for concrete ties as given in Part I, §213.109, additional inspections shall be made and conditions noted for:

  (1) The condition of flexible tie splices in the crossover.

  (2) The condition of the Pandrol shoulders in the vicinity of the tie splices to ensure that these shoulders are not skewed or tightened.

(e) In all classes of track, at least 1/2 of the movement ties at any switch machine shall be effective.

(f) Each 39' segment of track in a turnout must be supported by a minimum number of effective ties as given in the following tables:

| **WOOD TIE REQUIREMENTS**<br>**Each 39' segment of track shall have the minimum number of effective ties indicated below** | | | |
|---|---|---|---|
| **Class of Track** | **Turnouts and curved track over 2°** | **Maximum distance between effective ties (center to center)** | **Maximum number of successive defective ties (normal spacing)** |
| 1 | 6 | 100" | 3 |
| 2 | 9 | 74" | 2 |
| 3 | 10 | 74" | 2 |
| 4 | 14 | 60" | 2 |
| 5 | 14 | 50" | 1 |
| 6 | 14 | 50" | 1 |
| 7-9 | 18 | * | 1 |

**In Track Class 7, 8 and 9 there shall be at least three consecutive effective ties on both sides of a defective tie.*

| **CONCRETE TIE REQUIREMENTS**<br>**Each 39' segment of track shall have the minimum number of effective ties indicated below**<br>(Note: For the purposes of evaluation, a 39' segment of track is considered to consist of nineteen (19) concrete ties.) | | | |
|---|---|---|---|
| **Class of Track** | **Turnout and curved track over 2°** | **Maximum Number of successive defective ties** | **Minimum Number of effective ties on both sides of defective tie(s)** |
| 1 | 6 | 3 | 1 |
| 2 | 9 | 3 | 1 |
| 3 | 10 | 2 | 1 |
| 4 | 14 | 2 | 2 |
| 5 | 14 | 2 | 2 |
| 6 | 14 | 2 | 2 |
| 7-9 | 18 | 1 | 3 |

### §213.113(TO) Defective Rails

All rails within the turnout shall be inspected for defects in accordance with Part I, §213.113.

### §213.115(TO) Rail End Mismatch

The maximum allowable rail end mismatch for all classes of track is given in Part I, §213.115.

### §213.121(TO) Rail Joints

Rail joints in trackwork shall be inspected and meet the requirements of Part I, §213.121.

### §213.123(TO) Tie Plates/Switch Plates

(a) In Track Classes 3-9, there must be tie plates on at least 9 of any 10 consecutive wood ties.

  (1) In Track Classes 3-9, no metal object that causes a concentrated load by solely supporting a rail shall be allowed between the base of the rail and the bearing surface of the tie plate. Examples include tie plate shoulders, spikes, etc.

  (2) Canted tie plates shall be installed so as to ensure that the rail is canted inward

(b) The welds on switch plates and tie plates with welded shoulders, stops, etc. shall be visually inspected for cracks and breaks.

(c) Switch plates shall be inspected to see that the stock rails are seated properly in the plates.

(d) Switch plates that accept elastic or spring type fasteners to limit the movement of the stock rail shall be inspected to see that the fasteners are functioning as intended.

(e) Turnouts with raised switch plates shall be inspected for wear, breakage, and damage. Plates with elastic clips that cannot effectively control the horizontal and vertical movement of the stock rail shall be considered defective.

(f) PVT Plates requirements

  (1) More than two plates cracked/broken in a row in either rail: Replace broken or missing clips immediately; replace cracked/broken plates and install new pads as soon as possible; conduct daily inspections (on foot, with special attention to the cracked/broken plates) of the affected turnout(s) until replacements of the switch plates and pads are completed.

  (2) Three or more plates cracked/broken in a row in either rail: Place a 90 MPH protective speed restriction on the affected turnout(s) immediately; replace broken or missing clips immediately; replace cracked/broken plates and install new pads as soon as possible; conduct daily inspections (on foot, with special attention to the cracked/broken plates) of the affected turnout(s) until replacements of the switch plates and pads are completed.

### §213.123.5(TO) Tie Pads

Missing, broken, and worn tie pads shall be replaced so that the integrity of the rail seat and fastening system for concrete ties is preserved.

### §213.125(TO) Rail Anchoring

(a) Rail anchoring shall be performed in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

(b) Turnouts shall be inspected to determine if there is rail movement within the turnout. Rail movement shall be controlled with the placement of additional rail anchors.

## §213.127(TO) Fastening Systems

(a) Cut spike or screw spike fasteners for wood ties and resilient rail fasteners for wood or concrete ties shall meet the requirements of Part I, §213.127.

(b) All rail and appliance fastening systems within the turnout shall be inspected to determine if they are performing their intended function of limiting the horizontal and vertical movement of the rail or associated turnout component (i.e., frog, wing rail, stock rail, switch point, frog point stops, switch machine, etc.).

(c) The bolts that hold the machine extension plates used with concrete turnouts and support the switch machine shall be inspected to ensure that the machine is being held securely and that there is no excessive motion between the machine and the operating or point detector rods.

(d) Turnouts with frog point stops in the area of the moveable point frog shall be inspected to ensure that all stop bolts are tight. Any loose stop bolts shall be tightened.

(e) All switch plates shall be inspected to ensure that the plate is clean and has been properly lubricated. Switch plates with switch point rollers do not need lubrication.

(f) Vapé-type inserts used to fasten switch plates to concrete ties in earlier version Balfour-Beatty turnouts should be inspected to see that the bolts are secure. Bolts in Vapé inserts are to be tightened to between 175- and 200-foot pounds. Any cracking of the concrete tie in the vicinity of the insert shall be noted on the inspection form.

(g) Rail fastening systems that are not performing their intended functions shall be replaced as soon as possible and shall be reported on the inspection form by location and tie number or shall be otherwise identified when the tie number is not available. A tie is considered defective if it contains missing or non-performing fasteners. See §213.109.

(h) Additional general information for rail fastening systems is found in Part II, §127.0(M).

### §213.133(TO) Turnouts and Track Crossings; Generally (FRA §213.133 & §213.353)

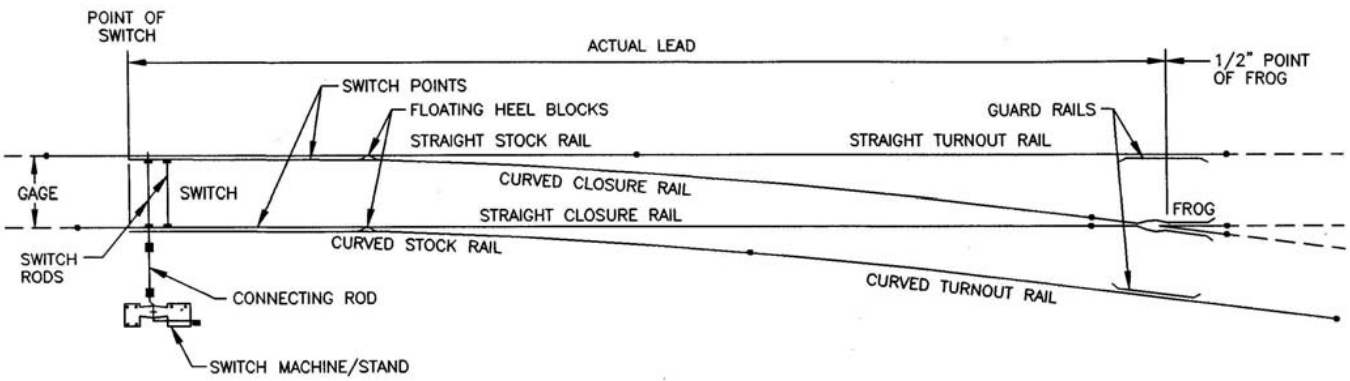
(a) Fastenings must be intact and maintained so as to keep the components securely in place. Also, each switch, frog, and guard rail must be kept free of obstructions that may interfere with the passage of wheels.

(b) Classes 3-9 track must be fully box anchored through and on each side of track crossings and turnouts to restrain rail movement affecting the position of switch points and frogs. Elastic fasteners designed to restrict longitudinal rail movement are considered the same as rail anchors

(c) The flangeway depth, measured from a plane across the wheel-bearing area of the frog, may not be less than 1-3/8" in Track Class 1 or less than 1-1/2" in Track Classes 2-9.

(d) Use of rigid rail crossings at grade is limited per Part I, §213.0347.

### §213.135(TO) Switches; General (FRA §213.135)




(a) Switch rails and movable points must be kept in good line and surface with all bolts tight and cotter pins in place.

(b) Each stock rail must be securely seated in switch plates with all braces and bolts tight. Care must be used to avoid canting the rail by overtightening the rail braces.

(c) Each switch point must fit its stock rail properly, with the switch stand in either of its closed positions to allow wheels to pass over the switch point. Lateral and vertical movement of a stock rail in the switch plates must not adversely affect the fit of the switch point to the stock rail. Ensure that each switch point fits snugly against its stock rail when the switch is thrown in either position.

 (1) The switch points shall have proper bearing against the head of the stock rail.

 (2) If wear pattern indicates bearing only along the top edge of a point, the cause of wear must be investigated.

(d) When a worn stock rail allows wheel flanges to cause excessive or accelerated wear on switch points, the stock rail should be replaced. Replacement switch points must not be installed against worn or mismatched stock rails.

(e) Unless otherwise designed (eg. Post, Stony), switch points shall be replaced when the raised portion of switch point is worn down to the level of the top of the stock rail. A raised switch point prevents the outside of a wheel from contacting the gage face of the stock rail.

(f) The heel of each switch point must be secure and the bolts in each heel (rigid heel block) must be kept tight. At least two tight bolts in each rail are required to ensure that the heel of each switch rail is secure.

(g) Each switch stand and connecting rod must be securely fastened and operable without excessive lost motion. Connecting rod bolts must be of the proper size and installed with the bolt facing upward and the nut on top. The upright bolt and nut shall be drilled to accept and installed with a cotter pin.

(h) Each switch stand throw lever must be maintained so that it cannot be operated with the lock or keeper in place.

(i) Each switch position indicator (target) must be clearly visible at all times.

(j) Metal overflow on the gage face of stock rails and on the back side of switch points should be noted on the inspection form. Flow must be removed by grinding to prevent deterioration and chipping of the rail steel and to maintain the proper fit of the switch point against the stock rail.

(k) Unusually chipped or worn switch points that are found to have an unprotected flat vertical surface 5/16" or more in width at a depth of 3/4" below the top of the stock rail and switch point must be removed from service and replaced. This type of point wear may contribute to wheel climb derailments.

(l) Chipping or wear on any switch point should be investigated, its cause determined, and corrective action taken. The wear or chipping produces a sloping surface on the face of the switch point that may tend to raise or lift a wheel having an imperfect flange. The switch rail should be further examined to locate any point of hard contact by the wheel that might contribute to wheel climb.

(m) Switch rails and matching stock rails shall be replaced when worn or chipped so that the top of the switch point, at any place, is more than 7/8" below the plane across the top of stock rail.

(n) The motion of the switch point, connecting, operating, and lock rods shall be observed when inspecting a turnout by reversing the switch points.

(o) Each switch point shall be inspected to ensure that the point sits properly against the stock rail. On powered switches, switch obstruction tests must be performed by C&S personnel at approximately 6" behind the point of switch. Adjustment of the operating rod on powered switches shall be made by the C&S Department to ensure that the switch point seats properly.

(p) Switch rods shall be inspected to see that the bearing connection on advanced technology turnouts and bolted connection to the switch point clip on conventional turnouts permits easy operation of the switch point.

(q) Any loss of motion in the switch rods shall be noted on the switch inspection report so that worn components can be replaced or switch clips tightened.

(r) Under no circumstances will the shimming of switch clips between the stock rail and lug plate be allowed. Shims shall be noted on the inspection report so that the proper switch rod or lugs can be placed in the turnout and the shims removed.

(s) All switches must have all switch rods and switch clips working as intended. There can be no defective or missing switch rods and switch clips unless approved by the Deputy Chief Engineer-Track.

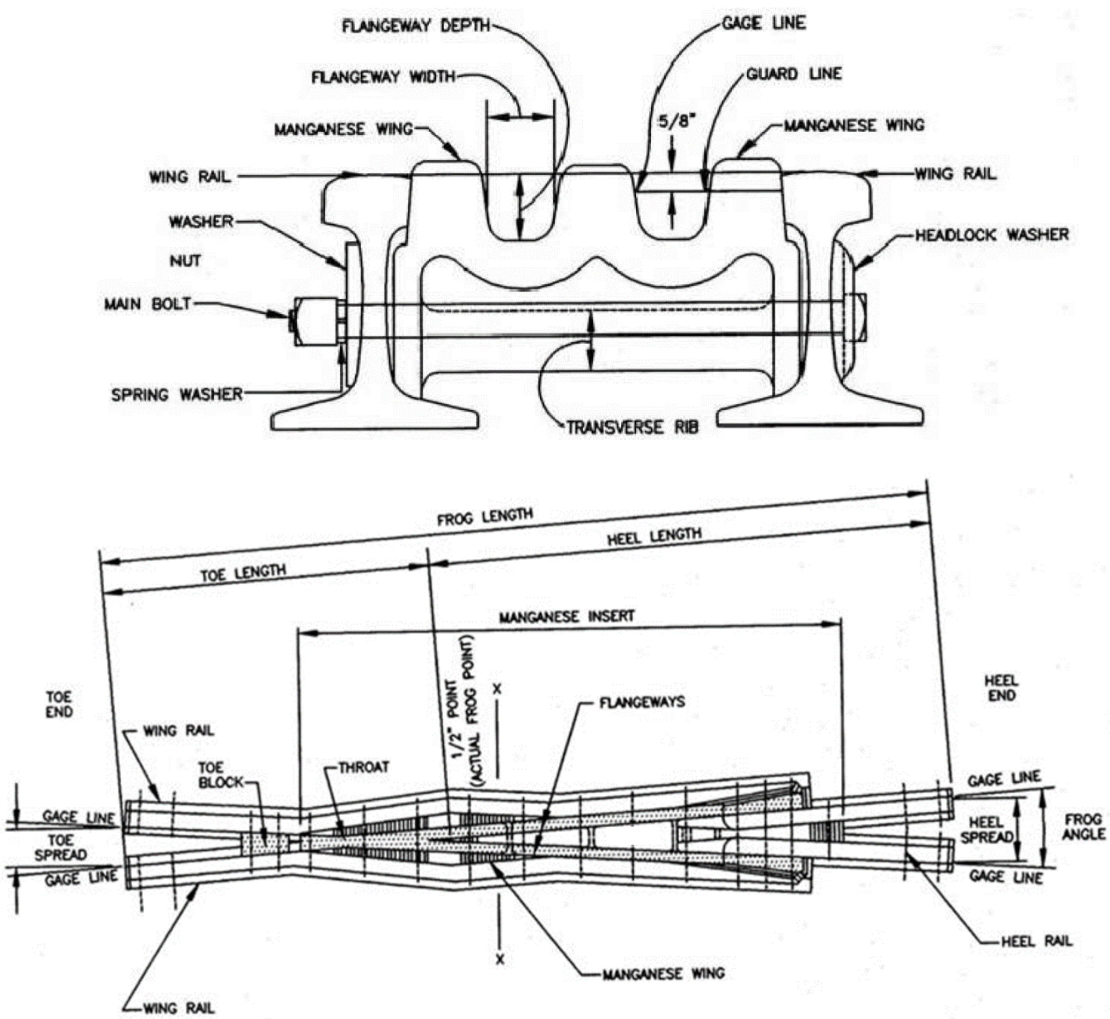
(t) Rail defects in switch points shall be governed by Part I, §213.113.

### §213.136(TO) Frogs; Wing Rails

(a) Any defect found in the portion of the wing rail contacted by the wheel tread or in the flex portion of the wing rail of a spring frog shall be treated as a rail defect as given in Part I, §213.113.

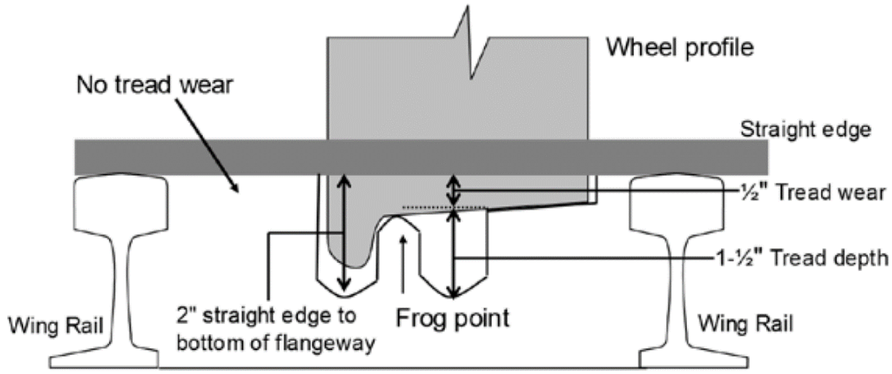
(b) An imperfect condition found in any portion of the wing rail that is not contacted by the wheel tread shall be treated on an individual case basis that considers the location and bolt support system.

### §213.137(TO) Frogs; General (Rail Bound Manganese and Welded Heel Manganese) ([FRA 213.137](FRA 213.137))



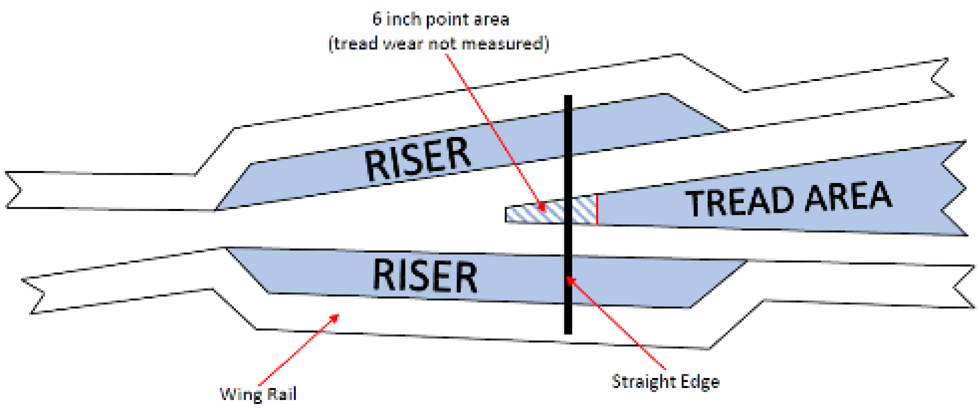

(a) Each flangeway at turnouts and track crossings must be at least 1-1/2" wide.

(b) The flangeway depth, measured from a plane across the wheel-bearing area of the frog, may not be less than 1-3/8" in Track Class 1 or less than 1-1/2" in Track Classes 2-9.



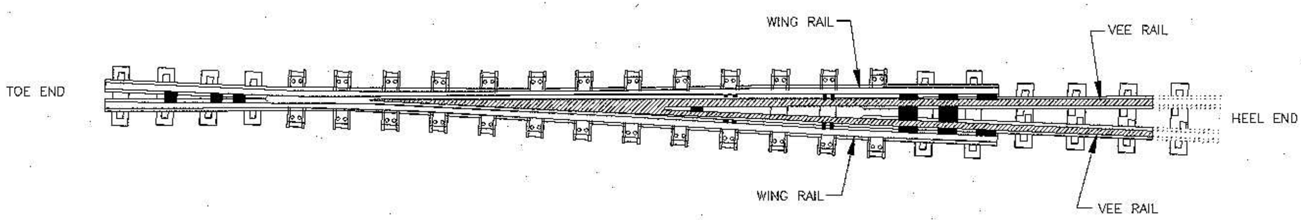

(c) If a frog point is chipped, broken, or worn more than 5/8” down and 6” back, operating speed over that frog may not be more than 10 MPH

(d) If a riser or tread area of a frog is broken out or worn down more than 3/8” below the original contour, operating speed over that frog may not be more than 10 MPH.




(e) The wheel wear pattern on the frog shall be observed by the inspector. Unusual wear shall be noted on the inspection report so that division forces can weld or maintenance grind the frog casting. The inspector shall identify the location and approximate depth and length of wear pattern. Missing or loose frog bolts shall be replaced or re-tightened in accordance with §160.0(TOM).

## §213.138(TO) Frogs; Moveable Point




(a) Moveable point frogs shall be inspected to ensure that the point is free from debris and both faces of the "vee" point are seated properly in the normal and reverse positions. Switch obstruction tests must be performed by C&S personnel at the detector rod location and the results of the test recorded on the proper switch inspection report.

(b) Unusually chipped or worn moveable points that are found to have an unprotected flat vertical surface 5/16" or more in width at a depth of 3/4" below the top of the wing rail must be removed from service and replaced immediately.

(c) Moveable point frog points and matching wing rails shall be replaced when worn or chipped so that the top, at any place, is more than 7/8" below the plane across the tops of wing rails.

(d) The motion of the moveable point frog and the connecting, operating, and lock rods shall be observed during the inspection of the turnout. This inspection is required to detect broken and missing parts, a point that is binding, linkage that is not complete or intact, or a point that has lost motion due to component wear.

(e) Adjustment of the operating rod shall be made by the C&S Department to ensure that the moveable point seats properly and that the frog point gap is 3/16" or less.

(f) Chipped, worn, or cracked frog points in the moveable point frog shall be noted on the inspection report so that division forces can make the appropriate repairs.

(g) The welding of a high carbon steel moveable frog point ("vee rail") must be done in accordance with Engineering Practice No. 2307. Before making repairs, consult with the Senior Engineer of Welding to determine the type of steel and the proper method and procedure for making the repair. The recommended methods and procedures may be driven by the location and size of defect. The Senior Engineer of Welding should be present to supervise the repair in cases where the welder has not made similar repairs as the conditions warrant.

(h) Lugs on the "vee" point shall be visually inspected with the aid of a mirror.

(i) If a moveable point frog lug is cracked or broken, the frog point must be immediately clamped to protect all train moves until the frog point is replaced. The repair of any moveable point lug by in track welding is not permitted. The frog lug repair will be made out of track at an Amtrak-approved welding shop.

(j) If any defects are found in the flexible rail area of the moveable frog, these defects shall be treated in accordance with Part I, §213.113.

(k) The width and length of any metal flow on the frog point or on the wing rails shall be noted on the inspection form so that division forces can perform grinding maintenance.

(l) All braces and frog bolts that are loose shall be reported on the inspection form.

(m) The stop flaps (frog bolt stops) on frogs at the Kearney Connection (Swift) should be inspected to see that all are properly bent to prevent frog bolts from loosening.

## §213.140(TO) Frogs; Jump Frog

(a) Diverging traffic speed is 10 MPH.

(b) On-Track Equipment must operate at walking speed on the diverging route.

(c) Guard Check gauge on the straight move must be checked from the running rail to the straight portion of the raised guard. Refer to the guard check gauge limits for frogs.

(d) Look for plate movement through the guard rail and frog area when measuring track and check gauges.

(e) All raised portions of the casting above the mainline rail surface shall be inspected for excessive flange contact during monthly switch inspection. Excessive contact, such as large gouges, indicates there is an issue that needs to be addressed.

(f) Any gouge made in the mainline running rails by the flange bearing wheels must not exceed ½" in depth as measured from top of running rail. If the depression in the mainline rail exceeds this, then the mainline track must be restricted to 10 MPH.

(g) Excess metal flow that protrudes into flangeway or develops around the groove in the rail must be removed by maintenance grinding.

(h) Visually inspect for cracks in running rail near the groove in rail. If any cracks are present the rail must be tested by Ultrasonic hand tester.

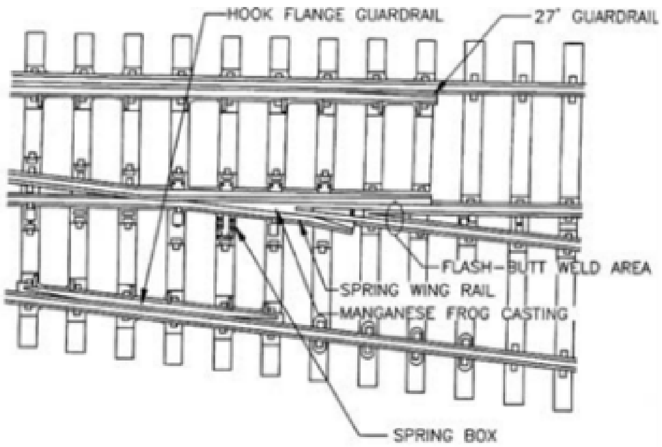
(i) All fasteners must be present and tight. Bolts that cannot be tightened must be replaced.

(j) Flangeway width must not be less than 1-7/8".

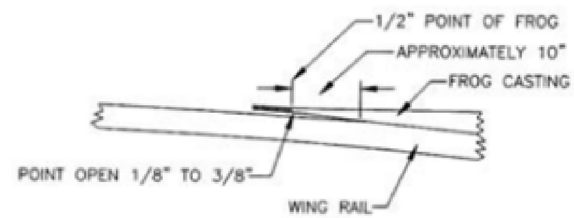
(k) If casting is found to be broken, remove the turnout route from service until replaced.

## §213.139(TO) Frogs; Spring Rail (FRA 213.139)

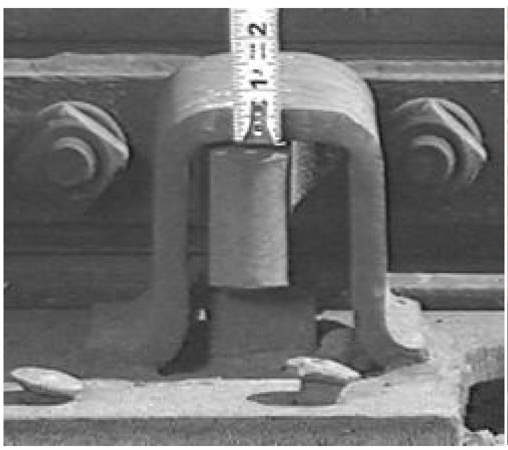
(a) The clearance between the hold-down housing and the horn shall not be more than 1/4”.




MANGANESE SPRING FROG LAYOUT




DETAIL OF SPRING FROG POINT AREA




(b) Typically, by design, there is a gap of up to 3/8" between the spring wing rail and frog point within the first 5" of the frog point. It is desirable to maintain contact between the spring wing rail and the remainder of the frog.

(c) The outer edge of a wheel tread must not contact the gage side of a spring wing rail.

(d) The toe of each wing rail must be solidly tamped and fully bolted.

(e) Any frog with a bolt hole defect or head-web separation must be replaced.

(f) Each spring must have sufficient compression force to hold the wing rail against the point rail.

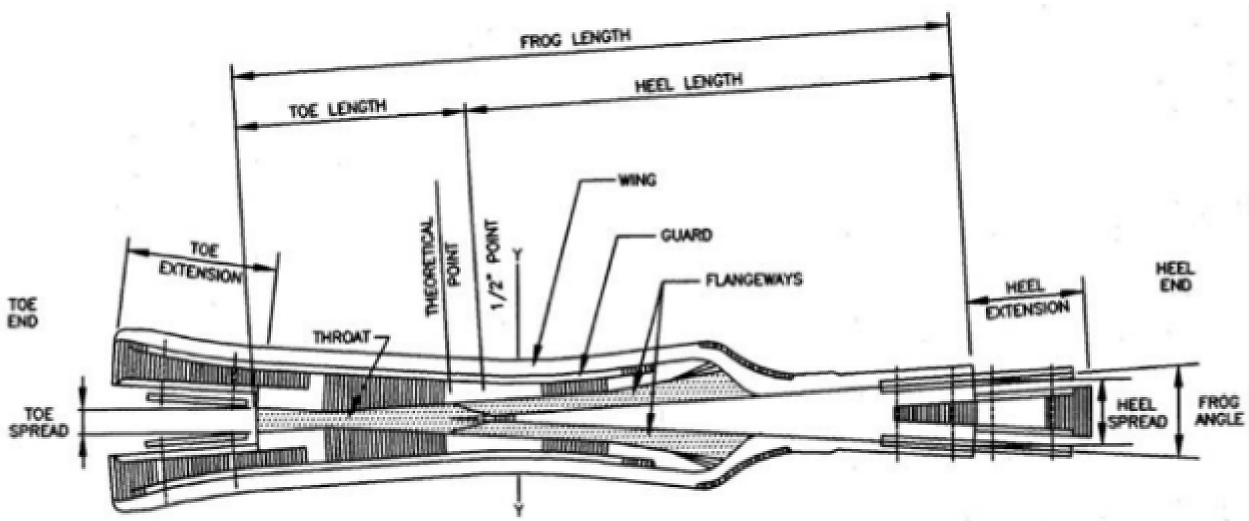
(g) The inspector shall check the opening between the spring wing rail and frog point of spring frog to ensure that there is no debris that may impede the operation of the spring wing rail.

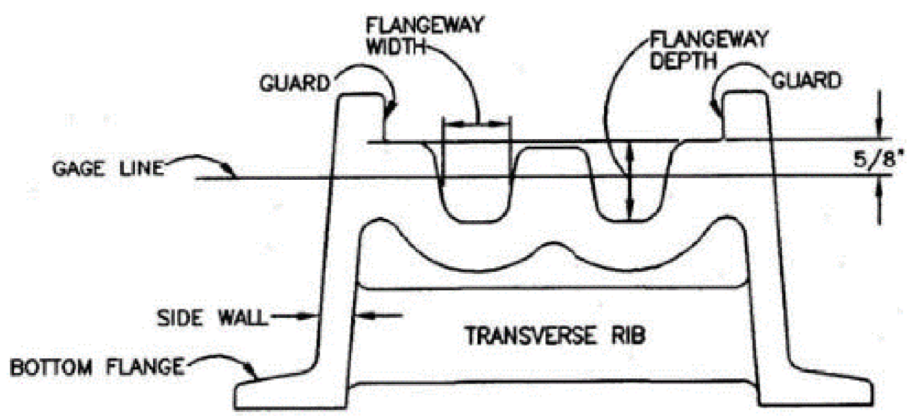
(h) The inspector, during the monthly switch and frog inspection, shall block the spring wing rail with a wooden wedge or other approved device for inspection (must be noted on the inspection report). The inspector shall visually inspect the spring frog and spring wing rail for breaks, cracks, chips, and unusual wear or debris. The inspector shall make use of a mirror as necessary to aid in making the visual inspection of the spring frog.

(i) While the spring wing rail is blocked in the open position the guard face gage (back-to-back) measurement must be taken.

(j) The inspector shall report all loose bolts found in a spring frog assembly. Bolts in the hold-down assembly and horns of a spring frog should be kept tight at all times.

**§213.141(TO) Frogs; Self-Guarded ([FRA 213.141](FRA 213.141))**




(a) The raised guard face on a self-guarded frog may not be worn horizontally more than 3/8". Wear measurements may be taken with a contour gauge. (See Part I, §213.251, Inspection Tools).

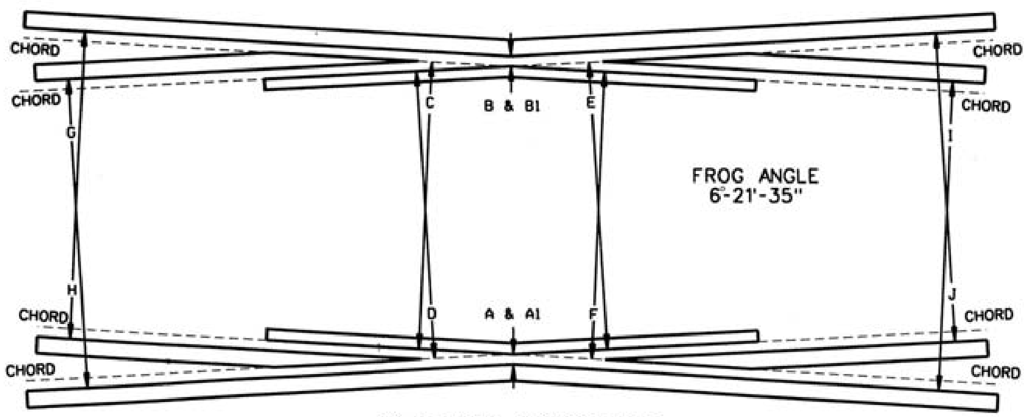
(b) If repairs are made to a self-guarded frog without removing it from service, the guarding face must be restored before rebuilding the point. This practice will ensure that a wheel does not strike a rebuilt frog point.

## §213.142(TO) Frogs; Solid Center Slip

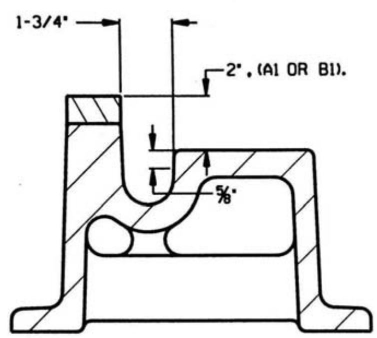
(a) No. 9 solid center frogs (for example, Chicago Union Station) shall comply with the following criteria:

| Measurement[1] | | Design (inches) | Limiting Values (inches) |
|---|---|---|---|
| A | Throat Opening | 1-3/4 | 1-3/4 to 2 |
| A1 | Guard Height | 2 | 1-7/8 to 2-1/8 |
| B | Throat Opening | 1-3/4 | 1-3/4 to 2 |
| B1 | Guard Height | 2 | 2 to 2-1/4 |
| C | Guard Face Gage | 53 | 52-3/4 to 53 |
| D | Guard Face Gage | 53 | 52-3/4 to 53 |
| E | Guard Face Gage | 53 | 52-3/4 to 53 |
| F | Guard Face Gage | 53 | 52-3/4 to 53 |
| G | Gage | 56-1/2 | 56-1/4 to 56-3/4 |
| H | Gage | 56-1/2 | 56-1/4 to 56-3/4 |
| I | Gage | 56-1/2 | 56-1/4 to 56-3/4 |
| J | Gage | 56-1/2 | 56-1/4 to 56-3/4 |

[1] Measurement locations shown in the following diagrams.




**No. 9 Solid Center Frog**

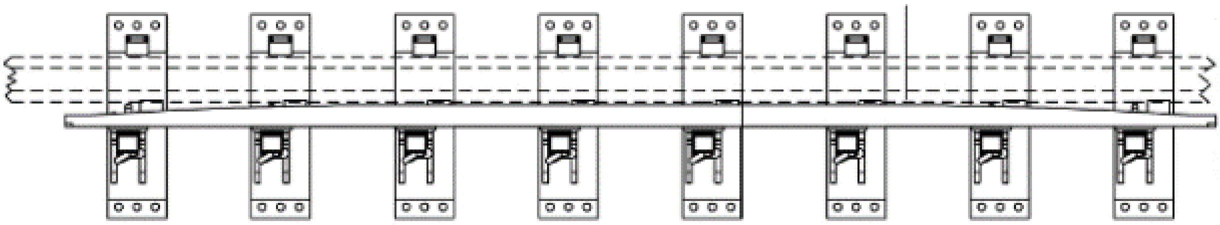



SECTION A THROAT

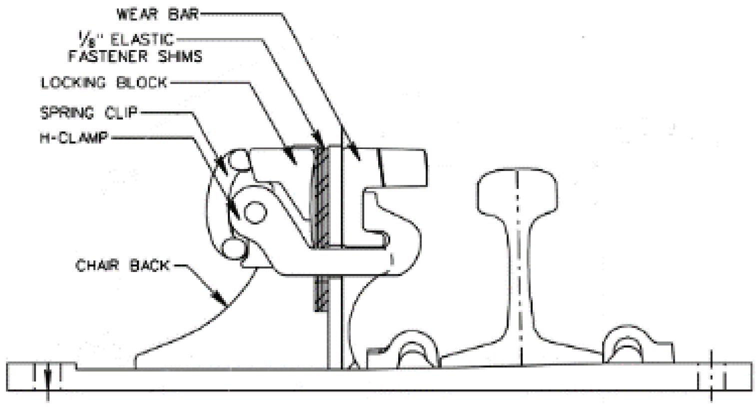
(b) These limitations supersede any other limitations found in this section.

(c) The diagram also shows the proper method of taking measurements within solid center frogs. This method of measuring can apply to all solid center frogs.

## §213.143(TO) Frog Guard Rails and Guard Faces; Gage (FRA §213.143 & 213.355)



**U-69 guard rail**




(a) The guard check gage and guard face gage for frogs must be within the limits prescribed in the following table. (Refer to Standard Track Plan AM 71801.)

| Class of Track | **Guard Check Gage** The distance between the gage line of a frog to the guard line[1] of its guard rail or guarding face, measured across the track at right angles to the gage line[2], may not be less than (inches): | **Guard Face Gage** The back-to-back distance between guard lines[1], measured across the track at right angles to the gage line[2], may not be more than (inches): |
|---|---|---|
| **1** | 54-1/8 | 53-1/4 |
| **2** | 54-1/4 | 53-1/8 |
| **3 and 4** | 54-3/8 | 53-1/8 |
| **5-9** | 54-1/2 | 53 |

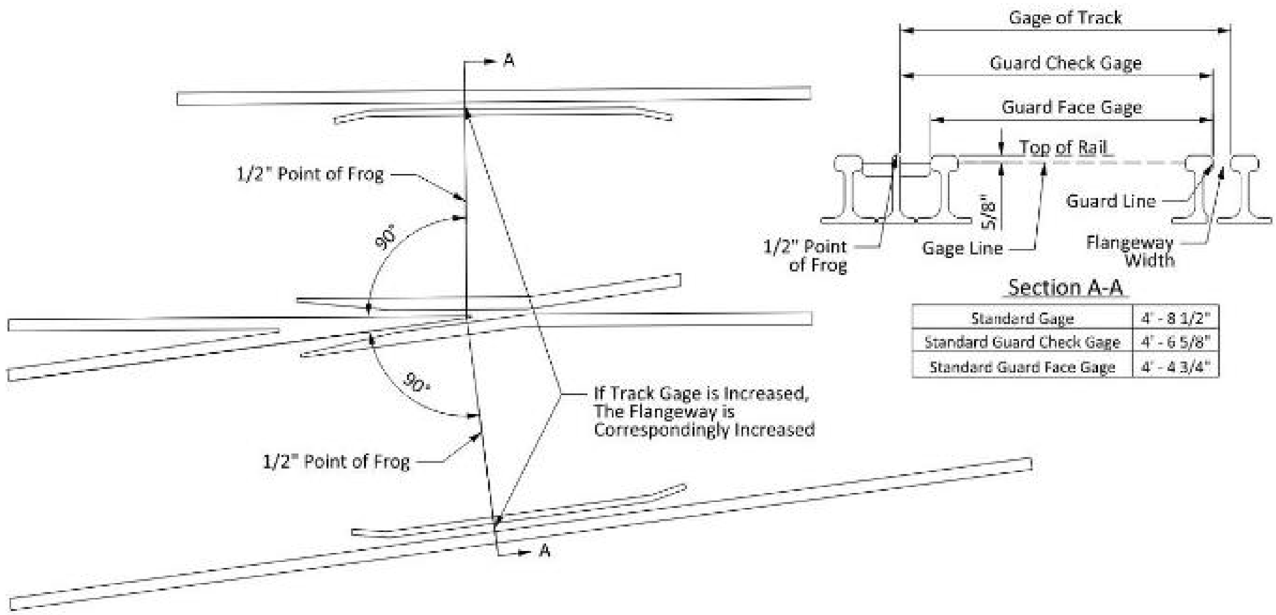
[1] A line along that side of the flangeway that is nearer to the center of the track and at the same elevation as the gage line.

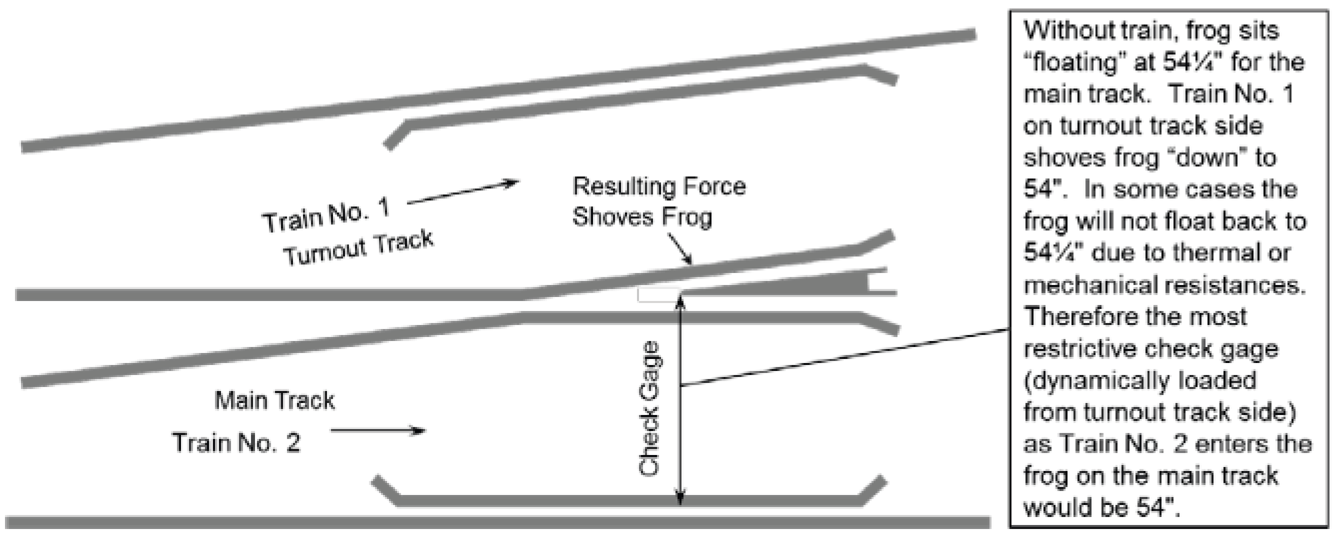
[2] A line 5/8" below the top of the center line of the head of the running rail or the corresponding location of the tread portion of the track structure.

(b) Guard Check Gage must be measured at the actual point of frog unless gage line cannot be established. If the gage line cannot be established, measurements may then be taken at up to 6” back.

(c) See §213.142(TO) for No. 9 solid center frog limitations.

(d) The relationship between the guard check gage and guard face gage is shown in the figure below:




**§213.144(TO) Crossings; One Way Low Speed (OWLS)**

(a) On Flange Bearing Crossings (OWLS Crossing Diamonds), any gouge made in the mainline running rails by the flange bearing wheels must not exceed 1/2" in depth as measured from top of running rail. If the depression in the mainline rail exceeds this the mainline track must be restricted to 10 MPH.

(b) Look for excessive wear on flange bearing surface and tread contact. Excessive contact, such as large gouges or extreme amounts of polish, are indicators that a problem is present.

(c) Grind excess metal flow at groove on the running rail.

(d) Visually inspect for cracks in running rail near the groove in rail. If any cracks are present the rail must be tested by Sperry hand tester.

(e) The horizontal alignment through the guard sections must be within +/- 1/8" as measured with stringline.

(f) All fasteners must be present and tight. Bolts that cannot be tightened must be replaced.

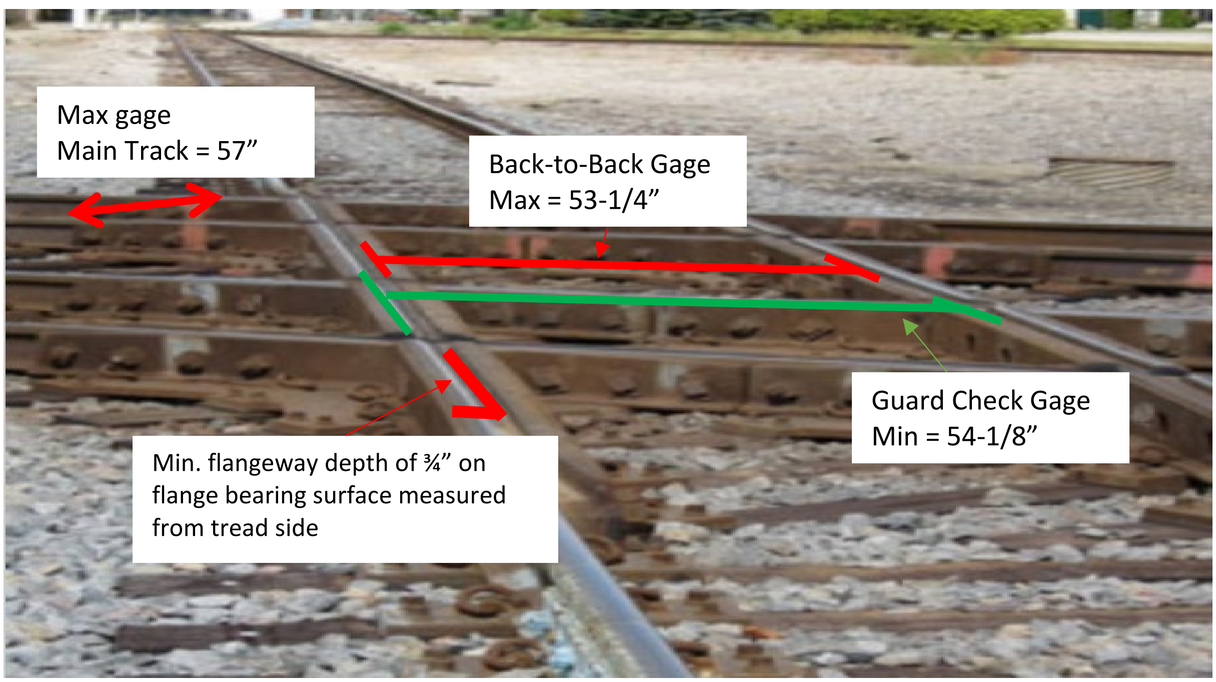
(g) Flangeway depth on flange bearing surface must not be less than 3/4", nor greater than 1", when measured from tread side.

(h) Minimum flangeway width is 1-1/2".


(i) Guard Check Gage must be 54-1/8" or greater.

(j) Guard Face Gage (Back to Back) must be 53-1/4" or less.

(k) Excess metal flow that protrudes into flangeway must be removed by maintenance grinding.




(l) If casting or running rail is found to be broken, remove from service until corrected.

### §213.205(TO) Derails (FRA §213.205 & 213.357)

(m) Each track, other than a main track, which connects with a main track with speeds 90 MPH or greater shall be equipped with a functioning derail of the correct size and type, unless railroad equipment on the track, because of grade characteristics cannot move to foul the main track.

(n) For the purposes of this section, a derail is a device which will physically stop or divert movement of railroad rolling stock or other railroad on-track equipment past the location of the device.

(o) Each derail on a track which is connected to a main track with speeds 90 MPH or greater shall be interconnected with the signal system.

(p) There are generally three types of derails: the "split switch", "sliding block" and the "hinged-block" types. For placement of derails see §205.0.

(q) Each derail must be made clearly visible with yellow paint.

(r) When in a locked position, a derail must be free of lost motion that would prevent it from performing its intended function or allow it to be operated without removing the lock.

(s) Each derail must be maintained to function as intended.

(t) When the lever of a remotely controlled derail is operated and latched it must actuate the derail.

(u) Each derail must be properly installed and of the proper size in accordance with Standard Track Plan AM 73920 & 73921.

(v) If a track protected by a derail is occupied by standing railroad rolling stock, the derail shall be in derailing position.

(w) All derails shall be inspected when making a turnout inspection.

(x) If track is protected by a derail, the normal position for the derail is in the derailing position.

### §213.207(TO) Switch Heaters

Switch heaters must be inspected to see that they do not interfere with the proper operation of the switch or otherwise jeopardize the safety of railroad equipment.

## Subpart C(TO) — Inspection Responsibility and Schedule

### §213.230(TO) Inspection Responsibility Matrix

(a) Turnouts shall be inspected by qualified individuals as described in Part I, §213.7 to protect the safety of operations and the traveling public.

(b) Individual responsibility for the inspection of trackwork and review of inspection documents is outlined in the table on the following page.

### §213.235(TO) Inspections of Switches and Track Crossings (FRA §213.365)

(a) In Track Class 1-5 each switch, turnout, and track crossing shall be inspected on foot at least monthly.

(b) In Track Classes 6-9 each turnout and crossover must also be visually inspected on foot at least weekly.

(c) All switches must be operated to all of their positions (normal and reverse) at least one inspection every three months. However, it is highly recommended that all switches are operated to all of their positions during every switch inspection.

(d) In the case of track that is used less than once a month, each switch, turnout, and track crossing must be inspected on foot before it is used.

(e) All main line switches must be inspected annually by a Division Officer with the Track Supervisor and a report submitted to the Deputy Chief Engineer-Track.

(f) In addition, any turnout in a track parallel to and centered within 30' of an Amtrak main track must be inspected monthly for compliance to its track class.

(g) Each frog and switch inspection report (monthly and annual) shall be reviewed and acknowledged by the required division personnel.

(i) During the search for internal defects in Part I, Sections 213.237, locations where the rail test vehicle cannot test due to physical limitations, track crossings and switch point derails, must be tested by hand once per year in Track Classes 3 thru 9. Switch point derails at bridge locations must be tested twice per year regardless of class of track.

| Turnout Inspection Responsibilities | | | | | |
|---|---|---|---|---|---|
| **Responsible Reviewer or Inspector** | **Daily Track Inspection** | **Weekly TO Inspection[1]** | **Monthly Joint TO Inspection and Test Report** | **Annual TO Inspection** | **Special Track Occurrence Report** |
| Track Foreman/ Inspector | ◆ | ◆ | ◆ | | ◆ |
| Track Supervisor | ❍ | ❍ | ❍ | ◆ | ❍ |
| Assistant Division Engineer | **AR** | **AR** | **AR** | ◆ | **AR** |
| Division Staff Engineer | ■ | ■ | ■ | ■ | ■ |
| Division Engineer | **AR** | **AR** | **AR** | **AR** | **AR** |

◆ indicates inspection responsibility
❍ indicates review responsibility
■ indicates responsibility to file and maintain inspection reports at the Division
**AR** review or inspect as required
[1] Include interlocking name and switch number on "Daily Track Inspection Report."

## Subpart D(TO) — Inspection Tools

### §213.250(TO) Tool Requirements

See Part I, §213.250 for a list of typical inspection tools.

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# SUBPART A-H

# LIMITS AND SPECIFICATIONS FOR TURNOUT (AND OTHER TRACKWORK) MAINTENANCE

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# LIMITS AND SPECIFICATIONS FOR TURNOUT (AND OTHER TRACKWORK) MAINTENANCE SUBPARTS A-H

**Track Classes 1-9**

## Table of Contents

## Subpart A(TOM) — General

### §1.0(TOM) Scope of Subpart

(a) This subpart is intended to provide guidance as to the types of maintenance and maintenance limits required for conventional turnouts, advanced technology turnouts, and other trackwork. All prescribed maintenance work shall make use of the appropriate Engineering Practices.

(b) This subpart shall be used by the Engineering Department forces to maintain a safe, reliable track structure in the most economical and efficient manner possible.

(c) Forces engaged in the repair of special trackwork and appliances shall be aware that their maintenance goal is to provide a safe and reliable track structure with a superior ride quality.

(d) Ensuring adequate spare material inventory for all trackwork is the responsibility of the Division Office.

### §2.0(TOM) Maintenance Responsibilities

(a) Supervisors in charge of making repairs and performing maintenance of turnouts and other trackwork under the provisions of Part II shall attend and successfully complete courses prescribed by the Deputy Chief Engineer-Track and administered by the Training Department.

(b) Individuals designated to supervise the maintenance, restoration, and renewal of trackwork shall be designated in accordance with MW 1000, Part I, §213.7.

### §3.0(TOM) Scheduled Maintenance

(a) Turnouts must be maintained on a regular basis to provide a safe and reliable track structure, to provide acceptable ride quality and to maximize the life of the turnout in track.

(b) The maintenance schedule for any turnout is driven by:

  (1) The location of the turnout.

  (2) The type, frequency, and accumulated tonnage over the turnout at that location.

  (3) The type and maintenance history of the turnout.

  (4) The requirements for maintenance as indicated on inspection reports.

## Subpart B(TOM) — Maintenance Program

### §5.0(TOM) Maintenance

(a) The responsible personnel in charge of performing the maintenance work shall be qualified to maintain, restore, or renew trackwork in accordance with Part I, §213.7.

(b) The person responsible for the work shall coordinate all work with and report the work performed to the local Track Supervisor.

(c) A record of all maintenance "work performed" on trackwork shall be maintained by the Track Supervisor.

### §6.0(TOM) Planning and Coordination

(a) The Division shall plan and coordinate all maintenance so that a comprehensive maintenance program can be developed. Programmed maintenance at the division level shall provide for the safety of train operations and shall be carried out in a cost-effective manner to provide maximum life to the trackwork and maximum benefit to Amtrak.

(b) The information contained in inspection reports shall be used to plan trackwork maintenance

### §7.0(TOM) Quality Control

(a) The person in charge of performing the maintenance activity or repair shall be responsible for the overall quality of the work performed.

(b) All maintenance work shall be performed in accordance with appropriate Engineering Practices, MW 1000, and Standard Track Plans.

(c) The Track Supervisor and Assistant Division Engineer shall periodically review the work performed for quality, consistency, and adherence to Engineering Practice.

(d) Trackwork repairs that are deficient:

  (1) May be cause for remedial action

  (2) Shall be brought to the attention of the local Track Supervisor

(e) The Track Supervisor shall see that any additional work necessary is performed to bring the repair into compliance with Amtrak standards and procedures.

(f) The Track Supervisor shall be responsible to re-inspect substandard or deficient work to ensure that the corrective work is in compliance with Amtrak practice, procedures, and standards.

(g) Division Officers, along with the Track Supervisors and Foreman, are encouraged to make recommendations to the Division Engineer or Deputy Chief Engineer-Track as to required modifications to methods, procedures, and practices to improve the overall quality of work.

## Subpart C(TOM) — Roadbed & Right of Way

### §33.0(TOM) Drainage and Waterways

Drainage in and around trackwork shall be maintained in accordance with Part I, §33.0(M).

### §37.0(TOM) Vegetation Management

Vegetation in and around trackwork shall be maintained in accordance with Part I, §37.0(M).

## Subpart D(TOM) — Maintenance Limits

### §50.0(TOM) Scope of Subpart

(a) Maintenance is the repair or replacement of a component of the turnouts or other trackwork which may include switch points, frogs and fastenings. Maintenance limits are to be used as a triggering mechanism that prompt maintenance or reconstruction. It is Amtrak's policy to have a turnout and other trackwork that stays between construction and maintenance limits. As the turnout and other trackwork components break down, maintenance should be programmed before the track reaches the maintenance limits. Maintenance must be executed whenever the maintenance limits are exceeded and completed prior to reaching the safety limits. Whenever possible, turnouts and other trackwork should be repaired or reconstructed to construction limits.

(b) The maintenance limits and specifications for turnouts and other trackwork are found in this subpart or the applicable maintenance section of Part I.

### §53.0(TOM) Gage

Trackwork gage shall be maintained in accordance with Part I, §53.0(M).

### §55.0(TOM) Alignment

Alignment measurements shall fall within the prescribed limits given in Part I, §55(M)

### §63.0(TOM) Track Surface

Track surface measurements shall fall within the prescribed limits given in Part I, §63(M).

## Subpart E(TOM) — General Maintenance Requirements

### §135.0(TOM) Switches

(a) Switch rails and movable points must be kept in good line and surface with all bolts tight and cotter pins in place.

(b) Switch rails and switch points must fit the stock rails closely and accurately, with a full bearing against the head of the stock rail. If a wear pattern indicates bearing only along the top edge of point, the cause of wear shall be investigated and corrected.

(c) Conventional and undercut stock rails must be milled or ground in accordance with the Standard Track Plans. Housed switch points and stock rails cannot be used in a turnout with a floating heel block.

(d) When necessary to replace switch points and stock rails, use undercut switch points and matching stock rails.

(e) Longitudinal movement of switch rails and stock rails should be prevented by adequately anchoring in accordance with Part I, §213.125 and §125.0(M).

(f) Bolts used with horizontal switch rods must be placed with nut ends up, and nuts locked by cotter pins.

(g) Fixed and floating heel blocks shall be installed and maintained per the Standard Track Plans.

(h) Switch plates and movable parts should be kept clean and lubricated with an approved graphite dry lubricant as specified in the Engineering Practice.

(i) Switch points shall be scheduled for replacement when worn or chipped so that the top of the switch point, at any place, is more than 5/8" below the plane across the tops of the stock rail so that the flange of the wheel does not contact the stock rail in a trailing point move.

(j) Chipping or wear on any switch point should be investigated, its cause determined and corrective action taken. Wear or chipping produces a sloping surface on the face of the switch point which may tend to raise or lift a wheel having an imperfect flange. The switch rail should be further examined to locate any point of hard contact by the wheel, which might contribute to wheel climb.

(k) Switch points shall be scheduled for replacement when the raised portion of the switch point (rise) is worn down to the level of the top of the stock rail. The purpose of the rise is to prevent the wheel from striking the stock rail in a trailing point move.

(l) Clearance must be maintained between the switch rods and adjacent ties to prevent the binding of switch rods and moveable point frog rods.

(m) Tie cribs that contain the switch rods and moveable point frog rods must be kept open to provide drainage and prevent a buildup of snow and ice in the winter.

(n) In main tracks, yards and terminals where the maximum authorized speed does not exceed 15 MPH, a switch point guard may be applied to the outside of stock rail. See Standard Track Plan AM 71812.

(o) All switch rails must be equipped with rigid or floating heel blocks.

(p) Switch rails, components, and connections must be examined frequently. It is important that the stock rails have no lateral movement in the switch plates and that switch plates have no movement on the ties.

(q) Non-standard length switch rails are only to be used as replacement in kind.

(r) All new switch points or stock rails used in conventional trackwork shall be heat treated or head hardened. Head hardened materials are preferred. When a switch point is replaced, the stock rail shall also be replaced. Converting a housed switch point and stock rail to an undercut switch point and stock rail is preferred.

(s) When new switch points are installed in advanced technology turnouts, they shall be heat treated or head hardened, undercut, and of asymmetrical design. Spring frog turnouts have conventional undercut points.

(t) MJS rods are used with all new slip switches. MJS rods should replace existing O'Brien rod assemblies when performing routine maintenance or when O'Brien rod insulation begins to fail. See Standard Track Plans AM 73615 and AM 73616 for MJS rod details, and Appendix F for trackwork examples.

**§137.0(TOM) Frogs; General**

(a) All metal flow from frogs must be ground promptly and the gage and guard edges of castings rounded. The radius shall be ground to match the original radius and contour of the frog. See the Standard Track Plans.

(b) Frog points, frog castings and wheel relief areas (false flange) should be built up by welding to maintain as new cross section. See Standard Track Plans. Spring rail frogs and moveable point frogs have false flange relief areas by design.

(c) If possible, worn frogs should be repaired in track by an approved method of welding or grinding. This does not apply to moveable point frogs.

(d) Each flangeway in trackwork must be at least 1-1/2" wide.

(e) Maintenance shall be performed prior to the flangeway depth reaching 1-3/8" in Track Class 1 or 1-1/2" in Track Classes 2-9. The flangeway depth is measured from a plane across the wheel-bearing area of the frog.

(f) Prior to the frog point being chipped, broken, or worn more than 5/8" down and 6" back maintenance shall be performed. This does not apply to moveable point frogs.

(g) Maintenance shall be performed on the riser or insert of a frog prior to the wear reaching 3/8” below the original contour.

(h) Welding repairs on manganese steel frogs shall be performed in accordance with Engineering Practice No. 2302.

(i) Missing or loose frog bolts shall be replaced or retightened in accordance with §160.0(TOM).

(j) All frogs requiring repairs that cannot be made in track, or at the site, may be shipped to the designated point for repair or reclamation.

(k) Frogs shall be fully tamped and supported on effective ties and timber to minimize wear and damage from train traffic.

**§137.1(TOM) Solid Center Frogs**

(a) No. 8 solid center frogs for slips have raised guards that are up to 1-5/8" above the wheel tread contact area. 1-5/8" is the standard. Guard heights designed for 1-5/8" are to be maintained from 1-1/2" to 1-3/4" above the wheel tread contact area. Periodic maintenance grinding of the guard top is required as the wheel tread contact area becomes worn under traffic.

(b) New No. 8 solid center frogs use a 1-5/8" guard. Original designs used a 1" raised guard. When replacement is required, frogs shall use same type guard heights. For example, if a single 1" raised guard type needs replacement and a 1" spare is available, it can be used. If both center frogs needs replacement, then a 1-5/8" raised guard type shall be used.

(c) No. 9 solid center frogs for slips have raised guards that are up to 2" above the wheel tread contact area. 2" is the standard. Guard heights designed for 2" are to be maintained from 1-7/8" to 2-1/8" above the wheel tread contact area. Periodic maintenance grinding of the guard top is required as the wheel tread contact area becomes worn under traffic.

(d) The proper method of measuring solid center slip frogs is shown in the diagram in §213.142(TO).

**§137.2(TOM) Frogs; Moveable Point**

(a) The welding of a high carbon steel moveable frog point ("vee rail") must be done in accordance with Engineering Practice No. 2307. Before making repairs, consult with the Engineer of Track-Welding to determine the type of steel and the proper method and procedure for making the repair. The recommended methods and procedures may be driven by the location and size of defect. The Engineer of Track-Welding should be present to supervise the repair in cases where the welder has not made similar repairs as the conditions warrant.

(b) Maintenance shall be performed on any unusually chipped or worn moveable points prior to the development of an unprotected flat vertical surface 5/16" or more in width at a depth of 3/4" below the top of the wing rail.

(c) Moveable point frog points and matching wing rails shall be scheduled for replacement prior to any wear or chipping, that at any place reaches more than 7/8" below the plane across the tops of wing rails.

(d) All braces that are loose shall be tightened.

(e) The stop flaps (frog bolt stops) on frogs at the Kearney Connection (Swift) should be properly bent to prevent frog bolts from loosening.

**§137.3(TOM) Frogs; Spring Rail**

(a) Maintenance shall be performed prior to the clearance between the hold-down housing and the horn measuring more than 1/4”.

(b) Typically, by design, there is a gap of up to 3/8" between the spring wing rail and frog point within the first 5" of the frog point. It is desirable to maintain contact between the spring wing rail and the remainder of the frog.

(c) The outer edge of a wheel tread must not contact the gage side of a spring wing rail.

(d) The toe of each wing rail must be solidly tamped and fully bolted.

(e) Any frog with a bolt hole defect or head-web separation must be replaced.

(f) Each spring must have sufficient compression force to hold the wing rail against the point rail.

(g) The opening between the spring wing rail and frog point of spring frog shall be kept free of any debris that may impede the operation of the spring wing rail.

### §137.4(TOM) Frogs; Self-Guarded

(a) Maintainenance shall be performed on the raised guard face on a self-guarded frog prior to the horizontal wear reaching 3/8". Repairs require the use of a contour gauge. (See Part I, §213.251, Inspection Tools).

(b) If repairs are made to a self-guarded frog without removing it from service, the guarding face must be restored before rebuilding the point. This practice will ensure that a wheel does not strike a rebuilt frog point.

### §143.0(TOM) Frog Guard Rail and Guard Faces; Gage

(a) Maintenance shall be performed prior to the guard face gage and guard check gage reaching the following limits:

| Frog Guard Rail & Guard Face Gage | | |
|---|---|---|
| **Class of Track** | **Guard Check Gage equal to or less than (inches):** | **Guard Face Gage (back-to-back) equal to or more than (inches):** |
| **1** | 54-3/8 | 53 |
| **2** | 54-7/16 | 52-15/16 |
| **3 and 4** | 54-1/2 | 52-15/16 |
| **5-9** | 54-9/16 | 52-7/8 |

(b) See §213.142(TO) for No. 9 solid center slip frog design criteria.

## Subpart F(TOM) — Scheduled Maintenance Activities

### §152.0(TOM) Lubrication of Switches and Frogs

(a) All switches (including hand thrown), moveable point frogs (MPF), and spring frog plates shall be cleaned as necessary and then lubricated at least four a year.

(b) The frequency of lubrication may increase as traffic and other local conditions warrant.

(c) Turnouts with frictionless switch slide plates shall NOT be lubricated.

(d) The C&S Department has the overall responsibility to lubricate switches and moveable point frogs that are powered by switch machines. In no case shall a non-C&S specified lubricant be applied to a switch or frog area that are powered by switch machines.

(e) Maintenance of Way Foreman and Track Inspectors shall inform local C&S Department personnel if powered trackwork needs lubrication.

(f) Lubrication of spring frog plates is performed by the Track Department and should be done during inspection of the frog, or as required.

(g) Lubrication shall be applied in accordance with manufacturer's recommendations in a manner that will limit the amount of free lubricant on plates, rods, bolts, etc.

### §152.5(TOM) Lubrication of New Switch Points, Stock Rails, Frogs and Rails on Curves

New switch points, stock rails, frogs and rails on curves shall be lubricated in accordance with Engineering Practice No. 1808. See Part I, §118.0(M).

### §153.0(TOM) Grinding of Frogs and Switch Point Areas

(a) Newly installed frogs, switch points, and adjacent rails require maintenance grinding to remove flow and restore the desired profile and head radius until the components become hardened by cold rolling under traffic.

(b) Switch points, MPF points, RBM frogs, SGM frogs, and spring frogs shall have maintenance grinding performed to remove metal flow, surface defects, and wear patterns and to restore the appliance to its original shape or contour.

(c) When a new frog or switch point is installed, or trackwork is replaced, out-of-face maintenance grinding is required. The Foreman shall:

    (1) Observe metal flow in newly installed components and remove flow as required

    (2) Inspect at a minimum, the flow on newly installed trackwork and components within 30 days after installation or after one million gross tons of rail traffic

    (3) Anticipate that additional grinding will be required as new components are subjected to rail traffic; therefore, regular grinding of trackwork shall be performed as local traffic and tonnage conditions warrant

(d) The maintenance grinding program shall include the removal of metal flow at:

    (1) Switch and frog points
    (2) Stock rails
    (3) Wing rails
    (4) Closure rails
    (5) Easer rails
    (6) Knuckle rails
    (7) Areas of false flange relief on the frog
    (8) Any wheel/tread contact areas

(e) Switch points and the moveable point frogs shall be reversed so that the back of the switch or frog points, stock rails, wing rails, and contact area of the point rail on the wing rail can be thoroughly inspected and ground for the removal of metal flow, as appropriate.

(f) A Signal Maintainer must be present when switch points or moveable point frogs are ground to ensure that the points seat properly after metal is removed. The maintainer must be present to make any necessary adjustments to the trackwork.

(g) The welding of switch points is prohibited.

(h) The welding of a high carbon steel moveable frog point ("vee rail") must be done in accordance with Engineering Practice No. 2307. Before making repairs, consult with the Engineer of Track-Welding to determine the type of steel and the proper method and procedure for making the repair. The recommended methods and procedures may be driven by the location and size of defect. The Engineer of Track-Welding should be present to supervise the repair in cases where the welder has not made similar repairs as the conditions warrant.

(i) Grinding or cutting back of worn, chipped or broken switch points to restore the original shape and height of the point is prohibited, except as provided in Engineering Practice No. 1900.

(j) Maintenance grinding shall be performed at spring frog turnouts to remove metal flow from the frog point area to permit proper closure of the frog against the spring wing rail. False flange wear on the spring wing rail shall be removed by grinding. See Engineering Practice No. 1303, "Maintenance of Spring Frogs."

**§154.0(TOM) Welding and Grinding of Welds, Forged Transition Areas, and Rail Head Depressions**

(a) Field and shop welds shall be measured at least twice each year for batter. Maintenance grinding shall be performed as required.

(b) The depth of low spots and depressions around welds, forgings, and other anomalies shall be measured with a 36" straightedge and taper gauge.

(c) The transition areas of switch point rail forgings in advanced technology turnouts shall be inspected for any "low" spots or depressions that develop in the rail head.

(d) The preferred method of removing low spots, low areas, and engine burns (but NOT engine burn fractures) in the rail head profile is by building up the rail head with weld as given in the Engineering Practice No. 2301, "Engine Burns Procedure."

(e) Grinding out low spots with a hand grinder is not permitted in advanced technology turnouts or in other turnouts operated at Track Class 6-9 speeds.

(f) Rails with multiple engine burns or engine burns greater than 1/8" should be repaired as soon as practicable before rail and tie damage occur. The repair of engine burns is especially important in concrete tie track or turnouts. Rail with multiple engine burns in track operated at Track Class 6-9 speeds should be removed from track

(g) Engine burns shall be welded by a qualified welder in accordance with Engineering Practice No. 2301, "Welding of Engine Burns."

### §154.5(TOM) Slotting of Mechanical Joints

(a) Permanent bolted joints shall be inspected and slotted as required to remove metal flow and prevent end chipping.

(b) When rails are replaced at the location of a permanently bolted joint, the rail ends should be slotted.

(c) The frequency of grinding or slotting rail ends at permanently bolted joint locations may increase if traffic and other local conditions warrant.

### §155.0(TOM) Production Grinding (Out-of-Face)

(a) Production grinding of rail in special trackwork shall be performed at regular intervals based on the condition of the rail, the number and type of trains and the accumulated tonnage at a particular location.

(b) Production grinding is required on all new rail installations to remove surface mill scale and impurities that can grow into surface defects.

(c) The FRA mandates that all Class 8 track have the CPF profile. This requires production rail grinding to achieve this shape. When more than 400’ of new rail is installed in these territories, reduction to class 7 speeds is mandatory until the production rail grinder can achieve the CPF profile.

(d) Production grinding is required control and/or remove surface anomalies on the rail head and to remove surface conditions that cannot be readily removed with the profile grinder used for maintenance grinding.

(e) Production rail grinding is required to remove flow and to restore the gage corner and head radius of the rail in and around trackwork. See Standard Track Plans for rail head and corner radii.

(f) Production grinding shall be used to remove such surface conditions as flakes, checks, shells, and corrugations.

(g) Production grinding shall be used to control rolling contact fatigue (RCF). By slowing the growth of RCF, the surface defects that arise from it will be eliminated.

(h) In all cases, a Signal Maintainer should be present when production grinding is completed to ensure that the frog and switch points seat properly and to replace any broken or damaged bonds.

(i) Out-of-face grinding of special trackwork should include grinding of the approaches for a minimum distance of 450'.

### §156.0(TOM) Spot Tamping (Surfacing)

(a) Tamping should be performed in such a way as to prevent the center binding of timber and ties. This is especially true for concrete tie turnouts.

(b) Switch machine extensions on advanced technology turnouts shall be supported on ballast and only tamped when necessary to level and support the switch machine. Regular tamping of switch machine extensions is not necessary and may damage or break concrete frog and switch movement ties.

(c) When spot surfacing, head block and movement ties may require tamping by hand.

(d) Spot tamping is required to restore the surface and line when deviations approach the alignment and surface maintenance limits given in this Part or in Part I, §55.0(M) and 63.0(M).

(e) Spot tamping is designed to limit the differential movement between various components and, as a result, limit vehicle-generated vertical and horizontal accelerations while passing through trackwork at maximum authorized speed.

(f) The Track Foreman shall have a track level board, string line kit, and other necessary inspection equipment to make line and crosslevel measurements before and at the completion spot tamping.

(g) Spot tamping is particularly important in concrete tie turnouts to minimize the differential movement between ties and the vertical deflection of ties. Spot tamping is required to eliminate the excessive deflection and pumping of ties which:

(1) Overstresses clips causing premature failure or backing out of clips.

(2) Increases tie pad and tie seat abrasion.

(3) Increases the wear on insulators.

(4) Increases ballast abrasion and wear.

(5) Changes the load distribution over the length of the tie which, in some cases, may overstress the tie.

**§157.0(TOM) Out-of-Face Surfacing and Alignment**

(a) In concrete tie turnouts it is particularly important to minimize the differential movement and deflection of ties. Excessive deflections and/or pumping of ties:

(1) Overstresses clips causing premature failure or backing out of clips.

(2) Increases tie pad and tie seat abrasion.

(3) Increases the wear on insulators.

(4) Increases ballast abrasion and wear.

(5) Changes the load distribution on the tie and in some cases may overstress the tie.

(b) It is recommended that out-of-face surfacing and aligning of newly installed trackwork be performed:

(1) At the end of the first year of operation after new trackwork is installed.

(2) At intervals when the trackwork accumulates 20 to 25 MGT (40,000 trains).

(3) More frequently if traffic and local conditions warrant.

(c) Out-of-face surfacing shall be performed in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

**§158.0(TOM) Spot Replacement of Major Components**

(a) During the useful life of trackwork, it may be required to replace major components and systems as part of a programmed maintenance activity. The major components include, but are not limited to:

(1) Switch points and stock rails.
(2) Switch plates or plates and clips, pads, and insulators.
(3) Frogs.
(4) Switch timber.
(5) Switch/Frog machines.
(6) Easer rails.
(7) Knuckle rails.

(b) The replacement of major components is based on:
   (1) The physical condition of the component.
   (2) The amount of measured wear on the component compared to an established maximum "wear limit" as given in this Part.
   (3) The ability of the component to sustain maximum authorized speed and meet the operational requirements of the Division.
(c) All work performed when changing major components shall be reported to the local Track Supervisor.

**§159.0(TOM) Spot Rail Replacement**

(a) Rail replacement shall be performed on as-needed basis as traffic and local conditions warrant.
(b) The replacement of rail is based on:
   (1) The physical condition of the rail.
   (2) The amount of measured wear on the rail compared to an established "wear limit" for that rail as given in Part I, §113.2(M).
   (3) Switch point to stock rail and moveable point frog to wing rail wear limits as given in this Part take precedence over the maintenance limits given in Part I, §113.2(M).
   (4) The ability of the rail to sustain the maximum authorized speed and meet the operational requirements of the Division or region.
(c) All work performed when changing major components shall be reported to the local Track Supervisor.

**§160.0(TOM) Bolts**

(a) Bolt replacement shall be performed on as-needed basis as traffic and local conditions warrant.
(b) The replacement of bolts is based on:
   (1) The physical condition of the bolt.
   (2) The ability of the bolted joint to sustain maximum authorized speed and meet the operational requirements of the Division or region.
(c) When evaluating the performance of bolts, the Foreman shall:
   (1) Verify that the bolt is of the correct diameter, length and type.
   (2) If possible, visually inspect the performance of the bolt under load.
   (3) If possible, visually inspect the joint or appliance and look for signs of vertical movement, batter, crushing, excessive flow or excessive wear in the component affixed with the bolt.
   (4) Visually inspect the condition of crib ballast and general line and surface at that location.
   (5) Visually inspect the condition of ties, plates, pads, insulators and clips at bolted locations.
(d) Bolts that are not the correct size and are not performing satisfactorily shall be replaced with new bolt assemblies. The use of excessive number of washers (more than 4) is prohibited.

(e) If two or more track bolts are changed in a mechanical joint in Track Classes 1-4, then all bolts shall be tightened.

(f) If two or more track bolts are changed in a mechanical joint in Track Classes 5-9, then all bolts shall be replaced within that joint.

(g) When a bolt is changed in a mechanical joint in Track Classes 1-9 or a frog bolt is changed, then all bolts in the mechanical connections shall be re-tightened

(h) After all bolt work is accomplished, the joint or frog shall be maintenance ground and/or slotted as required to restore the rail head or surface of the frog.

(i) When possible, the preferred method of tightening new bolts is with a torque wrench and multiplier that applies the recommended level of torque (foot-pounds) to the bolt.

| **Bolt Maintenance Torque Requirements (Preferred)** | |
|---|---|
| **Size Diameter of Standard Bolt (inches)** | **Preferred Dry Thread Torque (ft-lbs.)** |
| 7/8 | 470 |
| 1 | 710 |
| 1-1/8 | 960 |
| 1-1/4 | 1,350 |
| 1-3/8 | 1,750 |
| Vapé (Concrete Tie) | 175-200 |

### §161.0(TOM) Fasteners

(a) During the useful life of trackwork, it may be required to change rail fasteners (clips or spikes) as a normal maintenance activity.

(b) Fastener replacement shall be performed on an as needed basis as traffic and local conditions warrant.

(c) The replacement of fasteners is based on:

  (1) The physical condition of the fastener (broken or missing).

  (2) The ability of the fastener and the fastening system to minimize the horizontal and vertical movement of the rail or components (frogs and guard rail) and to sustain maximum authorized speed.

(d) All work performed when changing fasteners shall be reported to the local Track Supervisor.

(e) When evaluating the performance of fasteners, the Foreman shall:

  (1) Verify that the correct type of fastener is being used.

  (2) Visually inspect the fastener for cracks and breaks.

  (3) Visually inspect the base of the rail, switch, guard rail, frog or related appliance and look for signs of vertical or horizontal movement of the fastener and excessive wear of the fastener or wear of related components.

  (4) Visually inspect the condition of ties, pads, and insulators at clip locations.

(f) Fasteners that are not of the correct size and type and are not performing satisfactorily, shall be replaced with a new correct style fasteners.

(g) Fasteners shall be applied in accordance with the recommendations of the manufacturer and of this Part.

(h) Fasteners used in switches with built-up switch plates, to limit movement of the stock rail, should be inspected and replaced if missing or loose. There are two types in common use:

    (1) The PVT clip used in the Balfour-Beatty Turnout.

    (2) The Schwihag clip used on the Schwihag replacement PVT Plates.

(i) If one or more fasteners are changed at the location of a rail joint, at a frog, or at another trackwork appliance, then all fasteners at that location shall be checked to see that they are functioning properly and have not been overstressed. Defective fasteners shall be replaced.

(j) Whenever possible, clips that have backed out or fallen out should be replaced with new clips.

(k) All elastic fasteners shall be inserted into or removed from the cast-in-place shoulder (concrete tie) or tie plate (wood tie) with an approved device such as a "pan- puller" or sledgehammer as appropriate. The use of a spike maul is prohibited.

(l) Elastic fasteners should not be overdriven, as overdriving will cause premature relaxation of the fastener. Fasteners that have been overdriven or are not performing their intended function of limiting the vertical and longitudinal movement of the rail shall be replaced.

(m) In the case of the "e" clip, a distance of 3/8" (approximate width of a wooden pencil) between the shoulder and the face of the clip is required to prevent overdriving.

(n) When applying "e" clips (to include the "PR 601A") with a sledgehammer, the clip must initially be gently tapped to ensure proper insertion before the clip is fully seated. When removing "e" or "PR 601A" clips with a sledgehammer, the clips must initially be gently tapped to remove the toe load to ensure safe removal.

(o) During the insertion or removal of an "e" or "PR 601A" clip, no person can be located within 25' of the direction of sledgehammer swing.

(p) Care must be exercised so as not to strike the concrete tie or concrete tie shoulder in order to prevent damage to the tie. Striking a concrete tie to make adjustments in the alignment of the tie with any type device is prohibited.

(q) 15/16" diameter coach screws shall be used to secure cold rolled plates (1" diameter holes) with elastic fasteners to wood ties and timber. Coach screws must be screwed into a 11/16" diameter pre-drilled hole, 6" deep. Driving of coach screws with a sledgehammer or spike maul is prohibited.

(r) All spikes shall be driven with the head pointed toward the rail, except for spikes against sides of all joints, especially bonded and polyurethane-coated steel insulated joints, shall be driven with the head pointing away from the rail and not in solid contact with the joint bars.

(s) Spikes should not be driven at ends of insulated joints in any manner that would cause insulated joint bar to become electrically connected to the rail

(t) Spikes must be started vertical and square and driven straight. The shank of rail holding spikes must have full bearing against the base of rail. Spikes should be driven in accordance with Standard Track Plan AM 72051 being careful not to overdrive. The use of lock spikes (hair pins) is prohibited.

(u) Care must be taken not to strike the rail, its fastenings or signal appliances when driving spikes.

(v) Spikes in main tracks, when throat cut or deteriorated due to rust, should be replaced. All old spikes when pulled, shall be picked up, sorted and returned for reuse, if applicable, or scrapped.

(w) Track spikes (cut spikes) shall not be driven into round plate holes.

(x) All old spike holes shall be plugged with wood plugs prior to re-spiking.

(y) Slips use a double-clip stock rail brace hold down system. One clip is a conventional right-hand clip while the other is a left hand. Care should be taken to ensure an adequate inventory of these two different clip types.

**Dual Clip Brace (Slip Switch)**

### §162.0(TOM) Insulators and Pads

(a) Insulator and pad replacement shall be performed on an as-needed basis as traffic and local conditions warrant.

(b) The replacement of insulator and pads is based on:

- (1) The physical condition of the insulators and pads (cracked, broken, or missing).
- (2) The ability of the insulator/pad system to minimize the horizontal and vertical movement of components (frogs and guard rails) and to sustain maximum authorized speed.

(c) When evaluating the performance of pads and insulators, the Foreman shall:

- (1) Verify that the correct type of pads and insulators are being used. The preferred pad and insulator types to be used are shown on the Standard Track Plans.
- (2) Visually inspect the insulators for movement, cracks, and breaks.
- (3) Inspect to see that insulators are installed correctly (not upside-down).
- (4) In areas of loose or missing clips, visually inspect for:
  - i. Missing or crushed pads
  - ii. Twisted pads
  - iii. Worn, cracked or broken insulators
- (5) At locations with known insulator and pad problems, inspect ties, ballast, and other major components for damage. Perform any additional necessary maintenance as required.

(d) When practicable, when pads are replaced, the insulators shall also be replaced.

(e) When a pad or insulator is changed at the location of a rail joint, if practical, all pads and insulators at the joint shall be changed.

## Subpart G(TOM) — General Protection

### §170.0(TOM) General Procedures (Protection)

(a) When necessary to disconnect a movable point crossing or a derail from its operating mechanism, or to disconnect the No. 1 switch rod, the following precautions must be taken:

(1) The closed switch rail or movable point rail must be secured against the stock rail as required by §1.4(TOC).

(2) The switch must be blocked in position by driving a wooden wedge, as required by §1.4(TOC), between the open switch rail or movable point rail and the stock rail or knuckle rail.

(3) If a switch, movable point crossing or derail is in track circuit territory, or if its position controls the indication displayed by a signal, the work of disconnecting switch rods must be done by the Track Foreman in cooperation with the Signal Maintainer and C&S Department.

(4) Where both No. 1 and No. 2 switch rods are to be disconnected, train movements shall not be made over the switch until all rods are properly connected to the switch or movable point rails and the switch or movable point crossings are secured and protected as required by §1.4(TOC).

(5) If the open switch rail is removed, trains may be moved over the trackwork under the following conditions:

i. Trailing movements may be made after closed switch rail is secured as required by §1.4(TOC).

ii. For facing movements, in addition to properly securing the closed switch rail in accordance with §1.4(TOC), the near end of the connecting or lead rail must be moved away from the running rail to provide at least 5" clearance between rail heads and must be protected by a riser wedge fastened to the tie. Train movements shall be made only under a 10 MPH speed restriction.

## Subpart H(TOM) —Mechanisms, Appliances and Devices

### §200.0(TOM) Switch Operating Mechanisms

### §200.1(TOM) Use of Mechanisms

Switches shall be operated by approved types of mechanisms as follows:

(a) Power or manually operated switch mechanisms, in accordance with "Specifications for Signal and Interlocking Systems" (C. E. 234b).

(b) Spring switches: Manually operated switch mechanisms, which are supplemented by slow-acting spring devices that permit wheels to trail through switches set for the opposite route may be used with the approval of the Deputy Chief Engineer-Track, as follows:

(1) In tracks other than yard tracks, when they are equipped with electric switch lamp indication lamps, "SS" spring switch marker and facing point locking for the switch in its normal position and provided with signal protection in accordance with "Specifications for Signal and Interlocking Systems."

(2) In yard tracks, without facing point lock and signal protection.

(3) Spring switches.

i. Specially reinforced switch points for use with slow acting spring switch mechanisms will be used in main tracks.

ii. Where slow acting spring switch mechanisms are in service, maximum permissible speeds for trains and locomotives shall be:

| Maximum Permissible Speed: Spring Switches | | |
|---|---|---|
| **Train Movements** | **Turnouts Not in Yard Tracks Protected as in 200.1(b)(1)** | **Turnouts in Yard Tracks Protected as in 200.1(b)(2)** |
| Facing, or trailing non-spring switch | As otherwise authorized for turnout or track. | As authorized for turnout or track, but not to exceed 20 MPH |
| Trailing - Spring switch | As authorized for turnout or track, but not to exceed 45 MPH | As authorized for turnout or track, but not to exceed 20 MPH |

(c) Locking switch stands. Manually operated mechanisms, combined in one unit, that throw the switch rails and also provide for locking them in normal and/or reverse positions may be used as follows:

(1) In main tracks in automatic block territory.

(2) In main tracks, in other than automatic block territory, and in other tracks where switches are protected by signals controlled over track circuits.

(3) In tracks, other than covered in paragraphs (1) and (2) above, only when approved by the Deputy Chief Engineer-Track.

Approved types of mechanisms are:

US&S Style T-20 GRS Model 9

(d) Manually operated switch mechanisms: non-automatic type, which throw the switch rails may be used as follows:

Approved type of switch stand is:

New Century Standard Track Plan AM 73901

(e) Semi-automatic switch stands: Manually operated mechanisms, the position of which is automatically reversed by wheels trailed through a switch set for the opposite route, may be used in yards and sidings as authorized by the Deputy Chief Engineer-Track.

Approved types of stands are:

| | |
|---|---|
| Racor No. 20C and No. 22P | Standard Track Plan AM 73902 |
| ABC No. 22E with Tri-Glide Handle | Latches must be engaged for proper operation. |

When authorized to permit trains and locomotives to trail through a switch set for the opposite route, the color of the switch stand shall be yellow or orange. The color of the switch stand shall be black at other locations.

### §200.2(TOM) Application of Switch Stands

(a) Manually operated switch stands shall be placed so that the operating rod is in tension when the switch is set in normal position in main track and at the siding end of crossovers between main track and siding.

(b) Each switch in a crossover shall be equipped with a switch stand.

(c) Where crossover switches are protected by signals, a switch locking arrangement shall be provided in accordance with Standard Signal Plans.

(d) Where manually operated crossover switches between main tracks, or between main track and siding, are in signaled territory, mechanical switch locking shall be provided in accordance with Standard Signal Plans.

(e) Switch stands for all other tracks shall be located to serve the safety and efficiency of employees.

### §200.3(TOM) Location of Switch Stands

(a) Switch stands, except locking switch stands, with or without switch point position indicators and stands for indicators, must be placed so that the distance from the gage of the nearest rail to the center of the spindle will be:

(1) With a low mast and placed between tracks whose center-to-center distance is:

| Track center distance | Minimum distance from gage to center of spindle |
|---|---|
| 12'-2" to 13' | 3' 8-3/4" |
| Greater than 13' | 4'-1" |

(2) For stands not between tracks, a minimum distance from gage line of the near rail shall be 7' to center of the spindle.

(3) Where switches are so close together that switch position indicators, if of the same height, would not be separately visible from the locomotive cab, one stand should be placed further from the track than the other, preferably by a distance of 18" where track center distances permit.

(b) "Locking switch stands" shall be placed so that the center line of the lock bar is 30" from the gage of the stock rail for a US&S Style T-20 and 42" for a GRS Model 9.

### §203.0(TOM) Hot Box Detectors

### §203.1(TOM) Application

(a) At all hot box detector locations, special attention must be given to the maintenance of good gage, surface and line for 100' approaching and through the detector to ensure that the top of the rail is at proper height with respect to scanners and that the wheels are properly centered with regard to the gage of the track in passing over the detector.

(b) Rail joints should be at least 5' from the transducers.

(c) The rail on which the transducers are located should be effectively anchored.

(d) Guard rails on each rail shall be placed in the direction of travel ahead of the hot box detector to align wheels and axles before passing over the detector.

### §203.2(TOM) Protection During Trackwork

Whenever trackwork is to be done in the vicinity of the detector, which may affect the vertical horizontal relationship of the rails with respect to scanners, the C&S Department and/or the responsible party must be notified.

### §203.3(TOM) Interference by Metal Objects

Employees must be careful not to pass any iron or steel object closely over transducers (coils that are mounted on the side of the rail) between the time that a train has passed over the detector and until the train has passed the home signal in advance to avoid possibility of causing home signal to display stop aspect in face of the train.

### §205.0(TOM) Derails

### §205.1(TOM) Position

The "normal" position of a derail shall be to derail wheels of rolling equipment away from the main track or structure. The "reverse" position shall be to leave the rails unobstructed for free movement of the equipment.

### §205.5(TOM) Operation of Derails

(a) In signaled territory outside of interlocking limits:

    (1) Where the main track switch is protected by a switch and lock mechanism, the derail may be operated by a pipeline connected to the main track switch throwing and locking mechanism, which operates both the switch and the facing point lock.

    (2) Where a pipe-connected derail is not provided, an independently operated derail at fouling point shall be used. The derail must be equipped with a track circuit controller connected to the signal protecting the main track switch that will display its most restricting indication when the derail is not in derailing position.

    (b) In manual block territory, the derail may be operated by a pipeline connected to the main track switch stand in accordance with Standard Track Plan AM 73920, where considered necessary and authorized by the Deputy Chief Engineer-Track.

    (c) Lever stands of approved types may be used for operating derails. Where practicable, the distance from the center line of the lever stand spindle to the gage of nearest rail shall be at least 4'-1".

    (d) All derails not operated by pipelines shall be provided with standard switch stand and padlocks fastened to the tie by a chain and staple, so that the lever or derail can be locked only in the normal position.

### §205.6(TOM) Position Indication

The position of non-interlocked derails, normal or reverse, shall be indicated as follows:

(a) Where train movements are made at night, the derail shall be equipped with standard switch lamp with discs removed, displaying a purple light when in normal position to derail and a yellow light in the reverse position. Where authorized by the Deputy Chief Engineer-Track, a reflectorized target may be used instead of a self-illuminated light.

(b) In daytime, no other indication than the position of the derail itself is necessary.

### §205.7(TOM) Maintenance

(a) Derailing blocks shall be painted yellow; other parts of derails shall be painted black.

(b) Pipe connections for operating derails must be kept free from lost motion. All the fastenings must be tight and in correct alignment, and ties under supports must be sound. Frequent tests shall be made to ascertain if any switch levers can be thrown and latched without the derail moving to the correct position, either normal or reverse.

(c) Dirt and weeds must be kept away from derails. Ballast, snow and ice must be kept away from derails and pipe connections.

(d) When derails, other than those herein specified, are in use and giving satisfactory service, they should be retained until replacement is necessary.

### §210.0(TOM) Padlocks

(a) At all non-interlocked main and secondary track switches, throw levers of switch stands shall be secured by two latches (for normal and reverse positions) and locked by a standard switch padlock. The padlock is to be fastened by a chain to the switch stand or tie so that the switch can be locked only in the normal position.

(b) Where the switch is provided with a separate facing point lock not operated by the throw lever of the switch stand, the padlock shall be placed for locking the facing point lock lever only.

(c) The throw levers of switch stands in other than main secondary tracks shall be provided with latches, but shall be provided with padlocks only when authorized by General Superintendent.

### §220.0(TOM) Switch Stand Maintenance

(a) Switches, switch stands, and operating rods must be examined frequently. Broken, damaged, or missing parts shall be renewed immediately.

(b) Regular inspections shall be made and documented as required. If necessary, corrective action must be taken immediately.

(c) Worn switch latches must be replaced before the wear is sufficient to permit the switch to be opened without removing the padlock.

(d) The applicable requirements of §213.135(TO) and §213.135(TOM) must be met in maintaining and inspecting switch stands.

## §230.0(TOM) Switch Point Position Indicators

### §230.1(TOM) General

(a) To give a clear and distinct indication of the position of switch points, indicators shall be provided in addition to switch stands, except where it has been decided that due to the character of traffic, the indicator is not necessary.

(b) Switch targets and reflectorized targets are classified according to the height of the center of lens, disc or target above the track ties as follows:

 (1) Low — Not exceeding 1'-8"

 (2) High — 7'-2"

(c) Indicators should be used at non-interlocked switches as follows:

 (1) Low type, with reflectorized target, should be used generally in all tracks.

 (2) High type, with reflectorized target, should be used only at facing switches in non-automatic territory where sufficient visibility is not afforded by the low type.

(d) Indicators are to be installed in accordance with Standard Track Plans AM 73910, AM 73917 and AM 73919.

### §230.2(TOM) Application

(a) Switch targets may be placed on a low stand and connected to the switch points in accordance with Standard Track Plan AM 73910 or they may be placed directly on the switch stand.

(b) Targets shall be set at right angles to the track and perpendicular to the headblock ties. Where targets are used, the upward point of the inclined blade shall be away from the track, when the switch is set "normal" for the main track.

### §230.3(TOM) Maintenance

Switch targets should be kept clean and of uniform brightness and visibility.

### §230.4(TOM) Position Indication

(a) Position indicators for switch points shall be in accordance with the following table:

| Color Indications for Switch Point Positions | | |
|---|---|---|
| | **Switch Normal** | **Switch Reverse** |
| **Location of Switch** | **Targets** | **Targets** |
| **In main tracks** | White or Green | Red |
| **In all other tracks including siding switch or crossover between siding and main track.** | White or Green | Yellow |

(b) On spring switches, targets indicate:

 (1) Green when switch is in the closed and locked position.

 (2) Red when switch is in the unlocked or open position.

# SUBPART A-C

# LIMITS AND SPECIFICATIONS FOR TURNOUT (AND OTHER TRACKWORK) CONSTRUCTION

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**LIMITS AND SPECIFICATIONS FOR TURNOUT (AND OTHER TRACKWORK) CONSTRUCTION SUBPARTS A-C**
**Track Classes 1-9**

## Table of Contents

## Subpart A(TOC) — General

### §1.0(TOC) Trackwork

### §1.1(TOC) Criteria

(a) Turnouts and crossovers are designated by their frog number and should be used as follows or as designated by the Deputy Chief Engineer-Track.

(b) The No. 32.75 and No. 20 advanced technology turnouts are the preferred main line designs instead of the No. 15 and 26.5.

(c) Advanced technology turnouts provide superior ride quality as compared to conventional turnouts through the straight and diverging moves. As a general rule, they will be used in Track Class 4 or greater:

   (1) No. 32.75 advanced technology concrete tie turnout -- Use in interlocking plants for diverging from one main track to another main track where the desired diverging speed is up to 100 MPH.

   (2) No. 26.5 advanced technology concrete tie turnout with a straight movable point frog -- Use for diverging from one main line track to another main line track where the desired diverging speed is up to 80 MPH. Uses for the No. 26.5 turnout can include situations where the needed diverging speed is greater than 45 MPH and the length of 32.75 will not fit the situation. Note: The No. 32.75 and No. 26.5 turnouts have an additional limitation in that cab signaling for 80 MPH diverging moves, which require a special cab code that may not be compatible with all carriers operating through the turnout. Complete compatibility is needed prior to using this turnout.

   (3) No. 20.0 advanced technology concrete tie turnout -- Use in interlocking plants for diverging from one main line track to another main track or secondary track where the needed diverging speed is up to 45 MPH. They may also be used to connect to sidetracks or in other special wayside situations where it is not practical to use a No. 10 spring frog advanced technology turnout due to design or speed limitations.

   (4) No. 15 advanced technology concrete tie turnout -- Use in interlocking plants for diverging from one main track to another main track or secondary track where the desired diverging speed is up to 30 MPH. They may also be used to connect to sidetracks or other wayside tracks where it is not practical to use a No. 10 spring frog advanced technology turnout due to design or speed limitations. Note: The No. 15 movable point frog requires a slip or sliding joint through its diverging side making it a "handed frog."

   (5) No. 10 spring frog advanced technology concrete tie turnout -- Generally used at wayside locations on main track territory where the diverging speed is up to 15 MPH. Unless otherwise approved by the Deputy Chief Engineer-Track, a spring frog will only be used in locations where diverging moves over the turnout are less than 30% of the moves over the turnout.

(d) Construction of conventional turnouts is generally limited to use in Track Class 3 or less or in wood tie territory. It is not desirable to place a single wood tie turnout if it is surrounded by concrete tie track. Only in special situations where concrete track exists in low track speed territory or in other design limited situations, will the use of conventional turnouts with concrete switch ties be permitted with the approval of the

Deputy Chief Engineer-Track. To further reduce inventory and maintenance costs and to improve ride quality, all new conventional turnouts are to be of welded design, with floating switch heels, WBM frogs, and guard rails.

(1) No. 20 conventional turnout -- Use at interlocking plants for crossing over from one main track to another main track where the desired diverging speed is up to 45 MPH.

(2) No. 15 conventional turnout -- Use at interlocking plants for crossing over from one main track to another main track where the desired diverging speed is up to 30 MPH, or where the conditions do not justify or afford the lead distances required for No. 20 conventional turnouts.

(3) No. 10 conventional turnout with RBM frog -- Use in main tracks, sidings, terminals and yards where the desired diverging speed is up to 15 MPH. This is the preferred design over a No. 8 conventional turnout.

(4) No. 8 conventional turnout with RBM frog -- Use in yards and terminals where the desired diverging speed is up to 15 MPH. Should only be used where the use of a No. 10 or greater size turnout is not practical.

(5) No. 8 and No. 10 self-guarded frog (SGM) turnouts -- Use in yards and terminals where the desired speed for both straight and diverging is up to 15 MPH. SGM turnouts are only to be used when the use of an RBM frog turnout is not possible.

(6) Turnouts smaller than No. 8 may be used only with the approval of the Deputy Chief Engineer-Track.

(e) Construction of single or double slips is generally limited to terminal and yard usage where the speeds will not exceed 15 MPH (P). Existing locations that have greater operating speeds are exempt from this requirement. Construction speeds in excess of 15 MPH (P) require the authorization of the Deputy Chief Engineer-Track.

(1) No. 8 slips can consist of either moveable center points with knuckle and easer rail assemblies or solid center frogs. Solid center frog slips are the preferred design as they have few moving parts, require less maintenance, and have fewer switch machines.

(2) No. 9 slips can consist of either moveable center points with knuckle and easer rail assemblies or solid center frogs. No. 9 slips are not the preferred design and requires the approval of the Deputy Chief Engineer-Track for any construction.

(3) No. 10 slips or greater consist of moveable center points with knuckle and easer rail assemblies. Solid center frogs are not permitted with these slips because of the reduced frog angle.

(4) Construction of less than No. 8 slips requires the approval of the Deputy Chief Engineer-Track.

(5) Whenever possible, the approaches to slips should be on tangent. In general, slips are sensitive to curved approaches resulting in increased maintenance of alignment and wear of components. If curved approaches are required, slip design and degree of curvature must be approved by the Deputy Chief Engineer-Track.

(f) Crossings (diamonds) are generally found on Amtrak in terminals and yards. There are three major designs: manganese steel insert, solid manganese steel, and the bolted rail crossing (1, 2 and 3 rails).

(1) There are potential applications for all of these designs. The selection depends upon location, speed, cumulative tonnage, and tonnage variation between the different routes.

(2) In general, for most applications a manganese steel insert design is preferred. It is easily adaptable to either low or high angle crossing conditions.

(3) Solid manganese steel crossing design is generally used at medium to high angle crossing conditions. It requires a rail-to-manganese connection.

(4) The bolted rail crossing design should not be used at low angle crossing conditions. This crossing is sensitive to tonnage variations over its routes due to multiple rail construction. If used at higher angles, it should be of the two or three rail design.

(5) In addition, crossing (diamonds, can be categorized as a low, medium and high angle design as follows:
Low angle: less or equal to 30° Medium angle: 31° to 60° High angle: 61° to 90°

**§1.2(TOC) Speeds**

(a) Unless otherwise directed by Timetable speed. the maximum authorized speeds through diverging movements on level turnouts, located on tangent track will be as follows:

| Frog No. | Maximum Authorized Speed - MPH |
|---|---|
| 32.75 | 100 |
| 26.5 | 80 |
| 24 | 60 |
| 20 | 45 |
| 15 | 30 |
| 10 | 15 |
| 9 | 15 |
| 8 | 15 |
| 6 | 5 |

(b) Exceptions to the above table, including special trackwork or frogs greater than a No. 32.75 or less than a No. 8 must have the approval of the Deputy Chief Engineer-Track.

(c) When turnouts or crossovers are located in curved tracks, speeds must be adjusted to agree with Part I, §57.0(c), 59.0(c), 63.0(c) and 213.64(TO).

**§1.3(TOC) Geometry**

(a) The introduction of curvature between the heel of frog and the last long turnout tie should be avoided.

(b) The recommended minimum tangent distance between reverse curves or facing same hand turnouts is 100'.

(c) To the extent practicable, avoid placing turnouts and crossovers on curves, particularly on spirals or elevation runoffs at the ends of curves.

### §1.4(TOC) Installation

(a) Trackwork constructed in track or at the site shall be built to and conform to the Standard Track Plans.

(b) Prefabricated trackwork shipped in panels in accordance with approved plans may be used where economical.

(c) Care must be used in unloading and handling all trackwork, especially concrete tie turnouts. This includes handling and unloading from flatbed cars and assembling and loading onto transport cars.

(d) A 12" bed of clean ballast shall be provided with good drainage.

(e) When being constructed or renewed in existing main tracks, trackwork should be completely installed with switches connected to their operating mechanisms and properly adjusted before trains are permitted to move over the trackwork.

(f) Care must be used when installing trackwork panels to prevent rail bending, tie splitting or tie cracking. Concrete tie turnouts are more likely to be damaged during handling and installation because of the weight and type of materials used.

(g) Dragging ballast on newly installed trackwork, especially with concrete ties, requires great care. Ballast bagging to level and secure the trackwork or by other approved methods, at least under every other tie, is required to prevent tie breakage and plate or rail bending. As an alternative to ballast bagging, before the installation of trackwork, the bottom ballast should be dumped, spread and compacted to within 3" of the final elevation of the bottom of the switch ties.

(h) Initial surfacing lifts for concrete trackwork shall be limited to 1-1/2" increments, stabilizing between each lift. This size lift helps prevent tie breakage, and the bending of rail and plates in spring and moveable point frogs.

(i) Where only one switch rail (closed point) has been installed in a turnout under construction or renewal in existing main track, and it is necessary to move trains over the turnout on the main track, the following precautions must be taken:

  (1) All switch plates on the turnout side must be in the correct position and fully fastened.

  (2) The main track switch rail must be securely held against its stock rail by driving a spike in each of the first two ties back of the point and, where possible, spikes must pass through holes in the switch plates. In addition, the switch point must be secured to the stock rail by standard clamping devices. Unconnected ends of lead rails or the toe of the frog must be protected by a tapered wedge fastened to the tie to protect against dragging equipment.

  (3) The free end of stock rail must be fastened to prevent movement.

  (4) Facing point train movements shall only be made under a 10 MPH speed restriction unless point detection is provided.

(j) Where both switch rails have been installed, but not properly connected to the switch operating mechanism, the following must be done before trains are permitted to move on the main track over the turnout:

  (1) Switch rods must be installed.

  (2) The main track switch rail must be secured against its stock rail as required by paragraph (i)(2) above.

(3) The diverting switch rail (open point) must be blocked by driving a wooden wedge, not less than 18" long, between the switch rail and its stock rail. On wood ties, a wedge must be secured in place by means of a lag screw or heavy nail through one clip bolt hole and a piece of wood placed against the end of the wedge and spiked to the first and second ties ahead of the point.

(4) Unless the curved lead has been installed and spiked to prevent movement, a connecting rail shall be fastened to the heel of the open switch rail and moved away from the running rail so as to provide at least 5" clearance between rail heads.

(5) Facing point train movements shall only be made under a 10 MPH speed restriction unless point detection is provided.

(k) The main track guard rail must be correctly placed and spiked if the frog has been installed.

(l) Unconnected ends of lead rails or the toe of the frog must be protected by a riser wedge fastened to the tie.

(m) Where track is signaled, a switch circuit controller shall be installed by a C&S employee in accordance with the AMT23.

**§2.0(TOC) Switch Ties**

(a) To determine the number, size and length of switch ties required, see appropriate Standard Track Plans. In situations where switch ties are numbered, they shall be installed in consecutive order.

(b) Switch ties shall conform to Engineering Practice No. 1907.

(c) The time between unloading at job site and installation of wood ties should be minimized particularly with 21' and 22' timbers to avoid damage by warping and twisting due to exposure to the elements.

(d) The use of 21' and 22' timber should be avoided. Timber tie splice is used in lieu of long timber.

(e) When constructing crossovers with concrete ties, the track centers should be aligned to the nearest 6" increment if possible: i.e., 12'-6", 13'-0", 13'-6", and 14'-0". These track centers facilitate the use of concrete ties that are sized to the nearest 6" increment. This design practice eliminates the need for an excessive number of ties of various sizes to be kept in inventory.

**§3.0(TOC) Fasteners**

**§3.1(TOC) Application**

(a) All elastic fasteners shall be inserted into or removed from the cast-in-place shoulder (concrete tie) or tie plate (wood tie) with an approved device such as a "pan- puller" or sledgehammer as appropriate. The use of a spike maul is prohibited.

(b) Elastic fasteners should not be overdriven as overdriving will cause premature relaxation of the fastener. Fasteners that have been overdriven or are not performing their intended function of limiting the vertical and longitudinal movement of the rail shall be replaced.

(c) In the case of the "e" clip, a distance of 3/8" (approximate width of a wooden pencil) between the shoulder and the face of the clip is required to prevent overdriving.

(d) When applying "e" or the "PR 601A" clips with a sledgehammer, the clip must initially be gently tapped to ensure proper insertion before the clip is fully seated. When removing "e" or "PR 601A" clips with a sledgehammer, the clips must initially be gently tapped to remove the toe load to ensure safe removal of the clip.

(e) Care must be exercised so as not to strike the concrete tie or concrete tie shoulder in order to prevent damage to the tie. Striking a concrete tie to make adjustments in the alignment of the tie with any type device is prohibited.

(f) 15/16" diameter screw spikes shall be used to secure cold rolled plates (1" diameter holes) with elastic fasteners to wood ties and timber. Screw spikes must be screwed into a 11/16" diameter pre-drilled hole, 6" deep. Driving of screw spikes with a sledgehammer or spike maul is prohibited.

(g) All spikes shall be driven with the head pointed toward the rail, except for spikes against sides of all joints, especially bonded and polyurethane-coated steel insulated joints, shall be driven with the head pointing away from the rail and not in solid contact with the joint bars.

(h) Spikes should not be driven at ends of insulated joints in any manner that would cause the insulated joint bar to become electrically connected to the rail

(i) Spikes must be started vertical and square and driven straight. The shank of rail holding spikes must have full bearing against the base of rail. Spikes should be driven in accordance with Standard Track Plan AM 72051 being careful not to overdrive. The use of lock spikes (hair pins) is prohibited.

(j) Care must be taken not to strike the rail, fastenings or signal appliances when driving spikes.

(k) Throat cut, rusted, deteriorated or bent spikes are not to be used for construction.

(l) Any spikes that are pulled, shall be picked up, sorted and returned for reuse, if applicable, or scrapped.

(m) Track spikes (cut spikes) shall not be driven into round plate holes.

### §3.2(TOC) Rail Fastening Systems

(a) Track shall be fastened by a system of components that effectively maintains gage and alignment.

(b) When spikes and elastic fasteners are used, unless otherwise ordered by the Deputy Chief Engineer-Track, each rail shall be fastened to every tie in the following manner:

| Track | Rail holding spikes[1] | Plate holding spikes or coach screws[1] |
|---|---|---|
| | ***Conventional Tie Plates*** | |
| Tangent and curves under 1° | 2 | 1 |
| Curves 1° and over and trackwork except for curved closure rail | 2 | 2 |
| Curved closure rail of trackwork | 3 (1 field side; 2 gage side) | 1 (field side) |
| | ***Elastic Fastener Plates*** | |
| Tangent and curves under 1° | 2 Elastic Fasteners | 3 (2 field side; 1 gage side) |
| Curves 1° and over and trackwork | 2 Elastic Fasteners | 4 |

(1) Lock spikes (hairpins) are not to be used.

(c) The application of spikes shall be in accordance with §127.1 the above paragraph and Standard Track Plan AM 72051. Lock spikes are not to be used.

(d) Each concrete cross tie must have four resilient fasteners, four insulators and two tie pads in accordance with the Standard Track Plans.

(e) Each wood tie with a resilient fastener system must have four resilient fasteners.

### §4.0(TOC) Switches

All switches must be constructed in accordance with the Standard Track Plans.

### §5.0(TOC) Frogs

### §5.1(TOC) Use

(a) Frogs of various angles, as designated by frog number, shall be used with trackwork of the same number in accordance with §100.0(TOC).

(b) The service assignments of the various types of frogs shall be as follows:

(1) Movable point frogs, boltless frogs, spring frogs, welded heel manganese frogs, and rail bound manganese frogs shall be used in heavy traffic and/or high-speed tracks. These frogs are to be head hardened or heat treated, explosive hardened and epoxy bonded where applicable.

(2) No. 10 spring frogs shall be used in main track wayside turnouts to industrial tracks.

(3) Unless otherwise approved by the Deputy Chief Engineer-Track, a spring frog will only be used in locations where diverging moves over the turnout are less than 30% of the moves over the turnout.

(4) Self-guarded frogs should be used in yard tracks, only if necessary and where the speed does not exceed 15 MPH. Whenever possible, RBM frogs are the preferred design.

## §6.0(TOC) Frog Guard Rails

### §6.1(TOC) General

Guard rails shall be furnished in accordance with Standard Track Plans and specifications, or manufacturer's designs approved for use by the Deputy Chief Engineer-Track.

### §6.2(TOC) Use

(a) UIC 33 (U-69) Guard rails are the approved guard rail design for all new installations.

(b) Security type guard rails, without a filler block between the guard rail and running rail are not permitted in track.

(c) Guard rails with filler blocks, bolted "tee" type and one- piece manganese are permitted in track but are to be replaced with the hook flange type when renewal is necessary.

### §6.3(TOC) Length

(a) The following table indicates the lengths of approved type guard rails to be used with designated frogs:

| Frog Number | Length of Guard Rail |
|---|---|
| 15 & 20 | 13' or 20' |
| 6, 8 & 10 | 13' |
| 24 | 26’ |

(b) 29’ guard rails must be used on the main track side of No. 10 spring frogs.

(c) Special guarding applications shall be approved by the Deputy Chief Engineer-Track.

### §6.4(TOC) Design

(a) All guard rails should be set in accordance with appropriate turnout standard plans and Standard Track Plans as follows:

(b) The end of guard rails should be placed upon a tie or be otherwise protected, so that no loose or dragging object may become hooked on the guard rail ends.

## Subpart B(TOC) – Construction Limits

### §10.0(TOC) General

(a) Construction is the complete replacement of track structure, including turnouts and other trackwork, from subgrade to top of rail. It should always be the goal to complete construction projects to a zero tolerance. This is not always practical given such variables as rail rolling tolerances and manufacturing limitations. Therefore, construction tolerances have been developed.

(b) The limits and specifications for turnouts and other trackwork are found in this subpart or the applicable section of Part I (C).

(c) It is recognized that when fit materials are used in the construction of trackwork, it may be more difficult to meet these limits. However, it is always Amtrak's policy to construct track, trackwork and appliances within the limits specified in this subpart.

### §53.0(TOC) Gage

### §53.1(TOC) Gage Standard

(a) The standard gage for track, measured between the running rails at right angles to the alignment of the track, 5/8" below the top of rail, is 56-1/2". Gage on curves over 13°, and for the diverging routes of trackwork less than No. 8, will be specified by the Deputy Chief Engineer-Track.

(b) Track and turnouts shall be gaged by adjusting the rail opposite the line rail.

### §53.2(TOC) Gage Limits

(a) Gage shall be measured with a standard track gage or other authorized devices. These devices must be checked prior to daily use for accuracy. (See §213.250, 213.251)

(b) For construction, the following deviations from standard gage apply. When performing maintenance, provided that the gage is uniform, the following deviations from standard gage apply:

| Construction Gage Limit | | |
|---|---|---|
| **Class of Track** | **Minimum (inches)** | **Maximum (inches)** |
| 1-9 | 56-13/32 | 56-9/16 |

### §55.0(TOC) Alignment

(a) Alignment (general) is the physical appearance of the railroad as viewed from above, which consists of a series of straight lengths of track, referred to as tangents, connected by simple, compound or reverse curves.

(b) Alignment (line) is the condition of track in regard to uniformity of direction over short distances on tangents, or uniformity in variation in direction over short distances in curves.

### §55.1(TOC) Alignment Limits

(a) The following standards shall be used for the construction of new track, including turnouts and other trackwork, and for the restoration of existing track:

| Construction Standard for Tangent and Curved Track | |
|---|---|
| Class of Track | The deviation of the mid-ordinate from a 62' chord[1] may not be more than (inches): |
| 1 | 3/8 |
| 2-9 | 1/8 |

[1] The ends of the line or chord must be at points on the gage side of the line rail, 5/8" below the top of the rail head. Use line rail in accordance with Part I, §55.0(M).

(b) The alignment of track and superelevation on curves, in overhead electrified territory, must not be changed until proper notice has been given to the Electric Traction Department.

(c) Curve realignment changes must be made in accordance with Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR..

### §63.0(TOC) Surface

### §63.1(TOC) General

(a) Track surface is the relationship of opposite rails to each other in profile and crosslevel. Track profile is the running surface along the top of the grade rail. Crosslevel is the difference in elevation of opposite rails measured at right angles to the track alignment. The ideal surface is a uniform profile consisting of constant grades connected by vertical curves, with zero crosslevel on tangents and predetermined superelevation on curves.

(b) The profile of track being surfaced should not be raised above established grades, except under instructions from the Deputy Chief Engineer-Track, who will give consideration to the required elevations and clearances in tunnels, under catenary systems and overhead structures, and at interlocking plants, undergrade bridges, platforms and highway grade crossings.

(c) Any encroachment upon the published minimum overhead or side clearances from a track will not be permitted.

(d) Turnouts shall not be placed in curves without the approval of the Deputy Chief Engineer-Track.

(e) If turnouts must be built in curves, the reverse elevation limits shall comply with §63.2(M) or be as approved by the Deputy Chief Engineer-Track.

### §63.2(TOC) Surface Limits

(a) The basic tools for determining correct track surface are the standard track level and string line. The track level should be checked by the Supervisor-Track periodically and by the Foreman-Track, or employee inspecting track, each day it is used. If found to be incorrect, it must be accurately adjusted or replaced. Other approved devices may be used for determining crosslevel, but their accuracy should be determined by comparison with a standard track level in correct adjustment.

(b) When surfacing or raising track, one rail, which shall be the lower rail on curves and usually the line rail on tangents, shall be selected as the grade rail. The other rail must be brought to surface by adjusting the crosslevel as needed.

(c) The construction limits for track surface are contained below:

| Construction Track Surface Limits | | | | |
|---|---|---|---|---|
| | **Class of Track** | | | |
| | **1** | **2** | **3** | **4-9** |
| The runoff in any 31' of rail at the end of a raise may not be more than (inches): | 3/4 | 1/2 | 1/4 | 1/8 |
| The deviation from uniform profile on either rail at the mid-ordinate of a 62' chord may not be more than (inches): | 3/4 | 1/2 | 1/4 | 1/8 |
| The deviation from zero crosslevel at any point on a tangent and designated elevation in curves may not be more than (inches): | 3/4 | 1/2 | 1/4 | 1/8 |
| The difference in crosslevel between any two points less than 62' apart may not be more than (inches): | 3/4 | 1/2 | 1/4 | 1/8 |

(d) The difference in crosslevel between any two points less than 10' apart is designated as short warp and may not be more than (inches):

| Track Surface | Class of Track |
|---|---|
| | **1-9** |
| Short warp | 1/8 |

### §115.0(TOC) Rail End Mismatch Limits

Relay (fit) rail used in construction shall be installed so no mismatch between fit rails shall be more than that prescribed in the following table:

| Construction Limits Fit Rail | | |
|---|---|---|
| | **Any mismatch of rails at joints may not be more than the following:** | |
| **Class of Track** | **On the head of the rail ends (inch)** | **On the gage side of the rail ends (inch)** |
| 1-3 | 3/32 | 3/32 |
| 4 and 5 | 1/16 | 1/16 |
| 6-9 | 3/64 | 3/64 |

### §121.0(TOC) Bolts

(a) New bolts shall be used in construction.

(b) Preferred torque values for construction is given in the following table:

| Construction Bolt Torque Requirements | |
|---|---|
| **Diameter of Standard Bolt (inches)** | **Preferred Dry Thread Torque (ft-lbs.)** |
| 7/8 | 470 |
| 1 | 710 |
| 1-1/8 | 960 |
| 1-1/4 | 1,350 |
| 1-3/8 | 1,750 |
| Vapé (Concrete Tie) | 175-200 |

(c) Torque values shall be field verified with a calibrated torque wrench.

### §143.0(TOC) Frog Guard Rail and Guard Faces; Gage

(a) When constructing trackwork, the installation dimensions of guard rails as given in Standard Track Plan AM 71801 are shown below:

| Frog Guard Rail & Guard Face Gage | |
|---|---|
| Track gage | 56-1/2" |
| Guard check gage | 54-5/8" |
| Guard face gage (back-to-back) | 52-3/4" |

(d) The guard face gage distance (back-to-back) between the wheel flange face of the guard rail and the wheel flange face of the frog wing rail must be maintained at 53" or less regardless of the class of track.

## Subpart C - Miscellaneous Appliances

### §203.0(TOC) Hot Box Detectors

### §203.1(TOC) Application

(a) At all hot box detector locations, special attention must be given to the maintenance of good gage, surface and line for 100' approaching and through the detector to ensure that the top of the rail is at proper height with respect to scanners and that the wheels are properly centered with regard to the gage of the track in passing over the detector.

(b) Rail joints should be at least 5' from the transducers.

(c) The rail on which the transducers are located should be effectively anchored to restrict movement of the rail.

(d) Guard rails on each rail shall be placed in the direction of travel ahead of the hot box detector to align wheels and axles before passing over the detector.

### §203.2(TOC) Protection During Trackwork

Whenever trackwork is to be done in the vicinity of the detector, which may affect the vertical horizontal relationship of the rails with respect to scanners, the C&S Department and/or the responsible party must be notified.

### §203.3(TOC) Interference by Metal Objects

Employees must be careful not to pass any iron or steel object closely over transducers (coils that are mounted on the side of the rail) between the time that a train has passed over the detector and until the train has passed the home signal in advance to avoid possibility of causing home signal to display stop aspect in face of the train.

### §205.0(TOC) Derails

### §205.1(TOC) Position

The "normal" position of a derail shall be to derail wheels of rolling equipment away from the main track or structure. The "reverse" position shall be to leave the rails unobstructed for free movement of the equipment.

### §205.2(TOC) Use

Derails shall be used as follows:

(a) In main tracks, secondary tracks, controlled sidings and sidings, only where required by the Code of Federal Regulations, State Authorities, or where authorized by the Deputy Chief Engineer-Track.

(b) In all other tracks connected with main tracks except:

    (1) Where, on account of ascending grade and/or other local conditions, there is no possibility of rolling equipment drifting beyond a determined point of safety, which shall be indicated by a yellow stripe about 10" wide painted on the inside and outside of head, web and base of both rails, which must be kept clear of dirt and weeds and repainted as often as necessary. Where the track behind the fouling point is a through-running track up to the fouling point, a fouling point sign marked "FP" may be used in addition to the yellow stripe. (In determining the ascending grade that will prevent equipment from drifting beyond the point of safety, grades on the entire track must be considered. Wind pressure will cause rolling equipment to move against any ascending grade less than 0.5 percent.)

(2) Where slow-acting spring switches are authorized.

(c) With guiding rail guards where track is located between main tracks to make sure the derailed rolling equipment will not foul the adjacent track. If such a track is temporarily used to store cars, place a car stop close to the stored cars while the track is used for car storage, unless this is unnecessary because the track lies on an ascending grade.

(d) At other points (as car repair yards) where deemed necessary and authorized by the Deputy Chief Engineer- Track.

(e) In an outside main track, if temporarily used to store cars, place a derail close to the stored cars while the track is so occupied, unless made unnecessary by reason of an ascending grade. If the main track on which cars are stored is between other main tracks, place a car stop close to the stored cars instead of a derail, unless made unnecessary by reason of an ascending grade.

**§205.3(TOC) Derail Types**

(a) Derails are generally of three kinds: the "split switch," the "sliding block," and the "hinged block" type.

(b) Where derails are prescribed, the split switch type shall be used as follows:

(1) On any track connecting to a main track in 90 MPH or greater territory. MPH.

(2) Within interlocking limits, in main tracks and in secondary tracks.

(3) At non-interlocked and non-signaled branch line junctions.

(4) In all other tracks where it is possible for the speed of rolling equipment to exceed 15 MPH.

(c) Approved block type derails shall be used in other than main tracks with speeds less than 15 MPH at locations other than those in paragraph (b) above.

**§205.4(TOC) Applications**

(a) A derail shall be placed a sufficient distance back of the clearance point, not less than 12' to ensure that derailed rolling equipment will not foul the main or other protected track. Clearance requirements and track center distances are defined in Part I, §61.1(M).

(b) Methods for installing derails are shown on Standard Track Plans AM 73920 (sliding block), AM 73921 (hinged block) and AM 73925 (switch point).

(c) Switch point derails protecting moveable bridges shall use deflecting rails.

(d) Where tracks are not parallel at the derail location, or due to other local conditions, it may be necessary to use a deflecting rail to make sure that derailed rolling equipment will not continue moving over the ties to foul the protected track.

(e) Where deflecting rails are used:

(1) The minimum length shall be 18'.

(2) The nearest end shall be 10' from the derail.

(3) The flangeway opening at the end nearest to the derail shall be 4".

(4) The end farthest from the derail shall be set to provide a 12" clear opening between running rail opposite the derail and the deflecting rail.

(5) The deflecting rail shall be of a section and weight not greater than that of the running rails, and preferably less.

(6) The deflecting rail should be spiked to every tie with two rail holding spikes; one on each side of the rail base.

(7) Deflecting rails shall be fully anchored or otherwise secured to ensure that they do not move longitudinally.

(8) Neither tie plates nor rail braces are to be used unless special circumstances dictate.

(9) Existing installations of derails need not be changed to meet these provisions until renewals are otherwise necessary.

**§210.0(TOC) Padlocks**

(a) At all non-interlocked main and secondary track switches, throw levers of switch stands shall be secured by two latches (for normal and reverse positions) and locked by a standard switch padlock. The padlock is to be fastened by a chain to the switch stand or tie so that the switch can be locked only in the normal position.

(b) Where the switch is provided with a separate facing point lock not operated by the throw lever of the switch stand, the padlock shall be placed for locking the facing point lock lever only.

(c) The throw levers of switch stands in other than main secondary tracks shall be provided with latches, but shall be provided with padlocks only when authorized by General Superintendent.

**§220.0(TOC) Switch Stands**

(a) Switches, switch stands, and operating rods must be examined frequently. Broken, damaged, or missing parts shall be renewed immediately.

(b) Regular inspections shall be made and documented as required. If necessary, corrective action must be taken immediately.

(c) Worn switch latches must be replaced before the wear is sufficient to permit the switch to be opened without removing the padlock.

(d) The applicable requirements of §213.135(TO) and §213.135(TOM) must be met in maintaining and inspecting switch stands.

**§230.0(TOC) Switch Point Position Indicators**

**§230.1(TOC) General**

(a) To give a clear and distinct indication of the position of switch points, indicators shall be provided in addition to switch stands, except where it has been decided that due to the character of traffic, the indicator is not necessary.

(b) Switch targets and reflectorized targets are classified according to the height of the center of lens, disc or target above the track ties as follows:

a. Low — Not exceeding 1'-8"

b. High — 7'-2"

(c) Indicators should be used at non-interlocked switches as follows:

a. Low type, with reflectorized target, should be used generally in all tracks.

b. High type, with reflectorized target, should be used only at facing switches in non-automatic territory where sufficient visibility is not afforded by the low type.

(d) Indicators are to be installed in accordance with Standard Track Plans AM 73910, AM 73917 and AM 73919.

**§230.2(TOC) Application**

(a) Switch targets may be placed on a low stand and connected to the switch points in accordance with Standard Track Plan AM 73910 or they may be placed directly on the switch stand.

(b) Targets shall be set at right angles to the track and perpendicular to the headblock ties. Where targets are used, the upward point of the inclined blade shall be away from the track, when the switch is set "normal" for the main track.

**§230.3(TOC) Maintenance**

Switch targets should be kept clean and of uniform brightness and visibility.

**§230.4(TOC) Position Indication**

(a) Position indicators for switch points shall be in accordance with the following table:

| Color Indications for Switch Point Positions | | |
|---|---|---|
| | **Switch Normal** | **Switch Reverse** |
| **Location of Switch** | **Targets** | **Targets** |
| **In main tracks** | White or Green | Red |
| **In all other tracks including siding switch or crossover between siding and main track.** | White or Green | Yellow |

(b) On spring switches, targets indicate:

(1) Green when switch is in the closed and locked position.

(2) Red when switch is in the unlocked or open position.

**National Railroad Passenger Corporation**

# PART III

# LIMITS AND SPECIFICATIONS FOR MITER RAIL AND EXPANSION JOINT SAFETY, MAINTENANCE AND CONSTRUCTION

# MW 1000

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# SUBPARTS A-F

# LIMITS AND SPECIFICATIONS FOR MITER RAIL AND EXPANSION JOINT SAFETY

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**LIMITS AND SPECIFICATIONS FOR MITER RAIL AND EXPANSION JOINT SAFETY**
**SUBPARTS A-F**
**Track Classes 1-5**

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## Subpart A(MR) — General

### §213.1(MR) Scope of Subpart

(a) Safety limits are limits, once passed, that would require the immediate repair of track, slow orders, or removal from service. It is Amtrak's policy to have track that never reaches these limits.

(b) This subpart prescribes the minimum requirements and safety limits for the inspection of miter rail systems on movable bridges.

(c) In the case where differences may exist between these standards and those prescribed in 49 CFR 213 (FRA Track Safety Standards), the more restrictive shall apply.

(d) The limits and specifications for miter rails and expansion joints are found in this subpart or the applicable section of Part I.

(e) The requirements and limits apply where one of the described track conditions is found to exist in a single location. Where a combination of two or more of these conditions is found to exist at the same location, even though none are individually beyond safety limits, judgement must be used to determine the extent to which such combinations may require remedial action to provide for safe operations over that miter rail assembly.

(f) The requirements or limits also apply when a combination of two or more of the track conditions is found to exist, or where multiple occurrences of the same track conditions are found to exist within proximity of the miter rail.

(g) Joint inspections of miter rails and expansion joints should be made by the Communication and Signals (C&S) and Bridge and Building (B&B) Departments. The results of these inspections shall be reported on the appropriate inspection forms. These inspections shall be made to ensure the integrity and safety of all components and systems that make up the entire miter rail and expansion joint system on a movable bridge.

### §213.3(MR) Application

This subpart applies to all miter rails and expansion joints on movable bridges that Amtrak owns or maintains systemwide. Relevant portions of these provisions also apply wherever expansion joints are used on bridges that do not have miter rails.

### §213.5(MR) Responsibility for Compliance

(a) Primary responsibility for inspection of miter rails is delegated to the Track Department. In addition, the B&B and C&S Departments play key roles in these inspections and must, with the Track Department, participate in periodic joint inspections of all miter rail installations. In general, the Track Department is responsible for all track materials and components above the top of the tie, including rail steel and tie plates. The Structures Department is responsible for the bridge ties (steel and wood) and the linkage and connections to the lift rails (including lift lug pin and retainer bar). The C&S Department is responsible for items such as proximity switches and the circuit controller and associated linkages to ensure that miters are seated, wedges are fully driven and the trolley coupler is in place.

(b) When it is known by track supervision, or track supervision has responsible notice that a track does not comply with the requirements of this subpart, the following action must be taken:

    (1) Make initial notification (non-class-specific defects). See §213.22.

(2) Repair or improve the track.

(3) Reduce the operating speed to within a range for which the track does comply.

(4) Place the track out of service.

(c) Remedial action must be taken before the passage of engines or a train.

(d) When the inspector or responsible person in charge notes a deficiency or number of deficiencies, even if the miter rail or segment of track that includes a miter rail or track segment complies with the requirements of MW 1000, remedial action may be taken to protect the welfare and safety of the traveling public.

**§213.7(MR) Qualifications and Requirements for Inspectors**

(a) Individuals designated by Amtrak to inspect and supervise the maintenance, restoration and renewal of miter rails and expansion joints shall be designated in accordance with Part I, §213.7.

(b) Individuals making inspections of any track that includes miter rails and expansion joints shall be trained by and have met the requirements of the Training Department. Individuals successfully meeting these requirements shall be qualified by the Deputy Chief Engineer-Track.

**§213.9(MR) Classes of Track and Operating Speed Limits**

(a) Maximum authorized speed will be site specific as determined by the Deputy Chief Engineer-Track. Unless restricted to a lower-class operation, trains passing over a track with a miter rail and/or expansion joint shall not exceed the speeds indicated by the following table:

| **Maximum Authorized Speeds over Miter Rail Joints on Movable Bridges** | | |
|---|---|---|
| **Miter Rail Design** | **Maximum Track Class** | **Speed (F/P) (MPH)** |
| Long Point | Class 5 | 70/90 |
| Two-Piece Fabricated Rider Rail | Class 3 | 40/60 |
| PRR Type (i.e. Dock 1 track) | Class 3 | 35/35 |
| Sliding Block Type | Class 2 | 25/30 |

**§213.13(MR) Measuring Track Not Under Load**

When track, not under load, is measured to determine compliance with the requirements of this part and rail movement under load is apparent, that amount of rail movement must be added to the measurements taken. §213.15(MR) Penalties

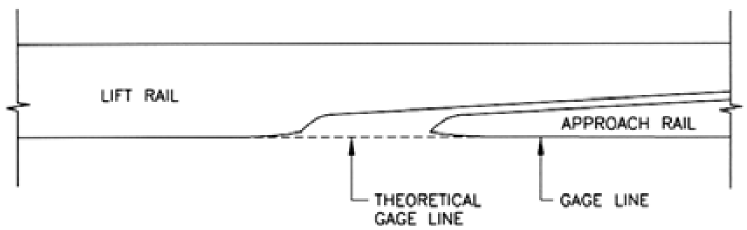
(a) If any requirement prescribed in this part is violated, the railroad and its employees may be subject to a civil penalty by the Federal Railroad Administration.

(b) For the purpose of this section, each day a violation persists is treated as a separate offense.

**Subpart B(MR) — Track Geometry§213.53(MR) Gage**

(a) At a minimum, gage measurements shall be taken at intervals of 1', 5', 10', and 15' on both sides of the point of the miter rail or expansion joint.

(1) The point of both miter rails and expansion joints may be recessed from the gage line. Use a 36" long straightedge to determine the locations ahead of and behind the point of the miter rails where the gage corner of the miter rail is in line with the theoretical gage line through the entire miter rail assembly. Miter rail gage shall be measured at those points.




(b) If the point of the miter rail projects beyond the theoretical gage line, take immediate action to correct the deficiency.

(c) Gage is measured between the heads of rails at right angles to the rails in a plane 5/8" below the top of the rail head.

(d) Gage measurements must comply with the requirements of the following table:

| Class of Track | The gage must be at least (inches): | But not more than (inches): |
|---|---|---|
| 1 | 56 | 57-3/4 |
| 2 and 3 | 56 | 57-1/2 |
| 4 and 5 | 56 | 57-1/4 |

**§213.55(MR) Alignment**

Alignment may not deviate from tangent more than the amount prescribed in the following table:

| | Tangent Track |
|---|---|
| Class of Track | The deviation of the mid-ordinate from a 62' chord[1] may not be more than (inches): |
| 1-3 | 1-1/2 |
| 4 | 1-1/4 |
| 5 | 5/8 |

[1] The ends of the line or chord must be at points on the gage side of the line rail, 5/8" below the top of the rail head. Use line rail in accordance with Part I, §213.55.

### §213.63(MR) Surface

(a) The surface of track shall not exceed the limits prescribed in the following table:

| | Class of Track | | | | |
|---|---|---|---|---|---|
| **Track Surface** | **1** | **2** | **3** | **4** | **5** |
| The deviation from uniform profile on either rail at the mid-ordinate of a 62' chord may not be more than (inches): | 1-1/2 | 1-3/8 | 1-1/8 | 1 | 5/8 |
| The deviation from zero crosslevel at any point on a tangent may not be more than (inches): | 1-1/2 | 1 | 7/8 | 5/8 | 1/2 |
| The difference in crosslevel between any two points less than 62' apart may not be more than (inches): | 1-1/2 | 1-1/8 | 1 | 7/8 | 3/4 |

(b) The difference in crosslevel between any two points less than 10' apart is designated as short warp and may not be more than (inches):

| Track Surface | Class of Track |
|---|---|
| | 1-5 |
| **Short warp** | 1-1/4 |

## Subpart C(MR) — Structure

### §213.105(MR) Scope

This subpart describes the minimum requirements for ties, fasteners and the physical conditions at miter rails and expansion joints.

### §213.113(MR) Bolt Hole Cracks in Rail, Castings, and Forgings

(a) If bolt hole cracks are found, the following remedial action shall apply:

(1) 1/2" or less: limit operating speed over defect to 50 MPH or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower. Inspect rail 90 days after it is determined to continue the track in use.

(2) Greater than 1/2" and up to 3": maximum speed 10 MPH (F)/15 MPH (P). Inspect rail 30 days after it is determined to continue the track in use.

(3) Greater than 3": visually supervise each move by a person designated under Part I, §213.7 at walking speed (not exceeding 4 MPH).

### §213.115(MR) Rail End Mismatch

(a) All rail ends shall be inspected for mismatch. This includes both the joint between the movable and fixed ends of a miter rail assembly and the connecting joints of miter rail and expansion joints.

(b) Rail end mismatch shall be measured with a 3' straight edge and a taper gauge to the nearest 1/16".

(1) Most miter rail and expansion joint designs recess the miter point inside of the gage line and below the nominal rail tread. The resultant variations from the normal surfaces on either side of the miter point are not "mismatch" and should not be reported as such.

(c) Mismatch in excess of these limits shall be repaired immediately or appropriate remedial action taken.

| Class of Track | Any mismatch of rails at joints may not be more than the following: | |
|---|---|---|
| | On the head of the rail ends (inch) | On the gage side of the rail ends (inch) |
| 1-3 | 3/16 | 3/16 |
| 4 and 5 | 1/8 | 1/8 |

### §213.117(MR) Rail End Batter

Rail end batter at miter rails shall comply with Part I, §213.117.

### §213.121(MR) Rail Joints in or Adjacent to Miter Rails and Expansion Joints

(a) All rail joints shall be of a structurally sound design and the proper dimension.

(b) If a joint bar is cracked, broken (other than between the middle two bolt holes) or because of wear allows excessive vertical movement of either rail when all bolts are tight, the track must be protected by a maximum speed restriction of 25 MPH (F) and 30 MPH (P) until the bar is replaced.

(c) If a joint bar is cracked or broken between the middle two bolt holes it must be replaced within 30 days. Until the bar is replaced, the track shall be protected by a speed not to exceed 10 MPH (F) and 15 MPH (P).

(d) If both joint bars are found to be broken entirely through between the middle two bolt holes, trains may be operated only under the visual supervision of a person designated under Part I, §213.7 at walking speed (not exceeding 4 MPH).

(e) Each rail end at a joint must be bolted with the proper number of bolts.

(f) For six hole joints bars the following applies. If one bolt in either rail end is missing or otherwise ineffective at a joint, the track must be protected by a 25 MPH (F) and 30 MPH (P) speed restriction until the missing or defective bolt is replaced. If one bolt is missing from both rail ends, or if two bolts are missing from one rail end, the track must be protected by a 10 MPH (F) and 15 MPH (P) speed restriction until the missing or defective bolts are replaced. If more than two bolts are missing from any location on a joint, trains may be operated only under the visual supervision of a person qualified under Part I, §213.7 at walking speed (not exceeding 4 MPH).

(g) For four and five hole joint bars, see Part I, §213.121 Rail Joints.

(h) For side bar joints in long point type miter rails, see §213.234.1 (MR).

(i) Repair of any miter rail joint bar or side bar by welding is prohibited. All defective parts shall be replaced.

### §213.123(MR) Tie Plates (Rail Fastener Plates)

(a) Fastener plates that support miter rails and expansion joints shall be in good condition. Examine for cracks, excessive corrosion, or other evidence that plates and the fastenings that anchor the plates to the bridge ties are not providing adequate vertical and lateral support to the miter rail.

(b) All rail fastener plates beneath miter rail and expansion assemblies shall be in place. If any plate is missing, train operation shall be restricted to walking speed (not exceeding 4 MPH) under the visual supervision of a person designated under Part I, §213.7.

(c) Fasteners that attach the plates to the bridge ties shall be inspected. Threaded elements shall be of the proper size and tight. If fasteners are missing or defective, a person designated under Part I, §213.7 shall determine the cause and take appropriate remedial actions.

(d) When, by design, miter rails or expansion rails are not supported by plates but are instead directly attached to bridge ties by spikes or threaded fasteners, the provisions of this section shall not apply; however, all fastenings between the miter rail or expansion rail and the bridge ties shall be tight. If fasteners are missing or defective, a person designated under Part I, §213.7 shall determine the cause and take appropriate remedial actions.

### §213.127(MR) Fastening Systems

(a) All rail fastening systems within the miter rail shall be inspected to determine if they are performing their intended function of limiting the horizontal and vertical movement of the rail and associated miter rail components.

(b) Rail fastening systems that are not performing their intended function, such as missing or defective rail clips, should be reported on the inspection report.

(c) When defective rail fastening systems are found at miter rails, a person qualified under Part I, §213.7 shall determine the cause and take appropriate remedial actions.

(d) Additional information for track fasteners is found in Part I, §213.127.

### §213.137(MR) Flangeways and Points

(a) Flangeway depth, measured from the top of rail plane across the track, shall not be less than 1-1/2" in all classes of track.

(b) If the point of a two- or three-piece type miter rail is chipped, broken or worn more than 3/8" down and 6" back, operating speed over the assembly shall not exceed 10 MPH.

(c) Unusually chipped or worn long point type miter rails or rail expansion joints that are found to have an unprotected flat surface and worn to a depth of 1/2" below the mated miter rail or sliding rail must be removed from service and replaced immediately.

(d) If the tread portion of a hollow manganese steel casting miter rail or expansion joint is worn down more than 3/8", operating speed over the miter rail shall not exceed 10 MPH.

(e) Each flangeway must be at least 1-1/2" wide.

### §213.143(MR) Guard Face and Guard Check; Gage

(a) Whenever a miter rail includes a guarding face opposite the mitered joint, use the limits given in the following table:

| Class of Track | Guard Gage Minimum (inches) | Guard Face Gage (Back-to-Back) Maximum (inches) |
|---|---|---|
| 1 | 54-1/8 | 53-1/4 |
| 2 | 54-1/4 | 53-1/8 |
| 3 and 4 | 54-3/8 | 53-1/8 |
| 5 | 54-1/2 | 53 |

(b) In-track welding of miter guard faces shall be accomplished by use of hard facing of the guard face by a qualified welder in accordance with accepted procedures.

## Subpart D(MR) — General Inspection Requirements

### §213.230(MR) Scope of Subpart

This subpart describes the frequency and manner of inspection of miter rails and expansion joints to detect deviations from the limits and requirements prescribed in this part.

### §213.231(MR) Inspections

(a) Inspection Schedule - Miter rails and expansion joints must be inspected on foot in accordance with the schedule prescribed in this paragraph by a person as designated under Part I, §213.7 and as described in §213.232(MR).

(b) Regularly scheduled inspections of each miter rail and expansion joint must be made in accordance with the following schedule:

  (1) Twice weekly, in accordance with §213.233(MR), a visual inspection must be made of each miter rail (closed position) and of all expansion joints.

  (2) Once a month a complete inspection is required of the entire miter rail assembly, including operating mechanisms and protection systems and expansion joint assemblies, conducted jointly with the B&B and C&S departments. A visual inspection of the miter rail must be made in both the open and closed positions of all miter rails. See Part I, §213.243 for inspection information.

  (3) Once a quarter, a division officer must be present during a monthly miter rail inspection as described in §213.232(MR).

(c) A complete inspection of the entire miter rail assembly, including operating mechanisms and protection systems conducted jointly with the B&B and C&S departments, must be conducted after any unusual event. Such events include, but are not limited to, the following:

  (1) Change out of a major miter rail assembly component or connection to the component by any department.

  (2) Impact to the movable bridge by a vessel, major debris or ice.

  (3) Derailment at or near the miter rail.

(d) In the case of a track that is used less than once a month, each moveable bridge lift rail assembly or other transition device shall be inspected on foot before it is used.

(e) During the search for internal defects as required in Part I, §213.237, locations where the rail test vehicle cannot test due to physical limitations, through miter rails, expansion joints and switch point derails (at bridge locations), must be hand tested twice a year regardless of class of track.

### §213.232(MR) Inspection Procedures

(a) Miter rails and expansion joints shall be inspected in accordance with the procedures indicated in paragraph (b) below and referenced appendices.

(b) General Requirements - The following applies to the inspection of all types of miter rails and expansion joints:

(1) Each miter rail and expansion joint shall be inspected at a frequency as described in §213.231(MR).

(2) All inspections of miter rails and expansion joints shall be made on foot.

(3) The inspector shall enter all measurement information on the appropriate miter rail inspection form during monthly inspections.

(4) A minimum of once a month, inspectors shall observe each miter rail in both the closed and the open positions. This observation shall be performed on no more than one track at a time. Miter rails on a single track shall be inspected by opening and closing the miter rails at each end of the bridge. Each pair of miter rails on each track on an end of the bridge shall be independently observed. Lift bridges and bascule bridges need not be fully opened during each inspection. During the monthly joint inspection by the B&B and C&S Departments, swing bridges shall be lifted and swung at least 5' out of square prior to being returned to the normal position.

(5) In the closed position, all components must be properly seated. During the monthly inspection, gaps between the fixed rail and the movable rail shall be measured, recorded, and compared against previously recorded values.

(6) During the opening and closing movements, observe any unnecessary, jerky, or unusual movement of the miter rail assembly. During closing, observe whether mating surfaces line up without being forced or requiring obvious realignment of the movable bridge span. All rails must be properly seated.

(7) Once a miter rail has been opened, verify with the bridge operator that the power to the miter rails' operating mechanism has been removed before proceeding with inspection of portions of the miter rail assembly that, if closed, could result in injury. Additionally, block the miter rail open with a bar or stout timber to prevent any accidental closure due to mechanical failure. Such blocking shall be promptly removed when no longer required.

(8) During the monthly inspection and special inspections, while the miter rail assembly is open, remove all grease and oil as may be required to conduct a thorough inspection. Examine contact surfaces for signs of unusual wear. Examine all surfaces for evidence of cracking or other failure. Examine bolts and other fastenings for tightness and any evidence of failures. The use of a mirror and supplemental lighting will be necessary to perform a comprehensive examination of some surfaces.

(9) When a crack of any length is found in any miter rail component, it shall be recorded and appropriate remedial action taken. Inspectors shall take steps to monitor the growth of any crack by taking measurements from fixed points. Center punch marks are recommended as a means of marking the limits of a crack at a particular inspection. Crack growth shall be monitored during subsequent inspections. The length or crack shall be recorded on the appropriate inspection form.

(10) Inspectors shall be alert for any changes in gage, alignment, profile or crosslevel in excess of 1/2" that may occur between track inspections as these may indicate a structural problem with the bridge itself. Such changes should be noted on the inspection report as a non-class-specific defect.

(11) Defects found may constitute an immediate hazard. If repairs cannot be made immediately, the track must be protected by appropriate remedial action, depending on severity of the defect.

(c) Required Measurements

(1) Required measurements are those necessary to confirm either compliance with, or deviation from, the established standards for the track class.

i. The required measurements described in this subpart are the <u>minimum</u> number of measurements to be made. Measurements are to be recorded on the appropriate inspection forms. See §213.242(MR).

ii. The inspector may take as many additional measurements as required to adequately describe the condition of the miter rail. All measurements made shall be recorded.

iii. Measurements made during an inspection shall be compared with the values observed during previous inspections and with the limits specified in this subpart.

(2) Measurements shall be recorded and described in such detail as to permit another inspector to take a subsequent measurement at the same location. Where describing the location is difficult, a permanent mark shall be made on the track structure to permit its recovery. Such marks shall be made in a manner that will not damage the track structure.

(3) Typical measurements that shall be made include the following parameters:

i. Gage

ii. Alignment

iii. Flangeway width and depth

iv. Guard face gage and check gage (when guarding is present)

v. Metal flow on the gage corner or other locations

vi. Gap opening at toe of miter rail between the fixed and moving components of the miter rail.

vii. Changes in width, length, appearance, etc. of any cracks or other visible deterioration of a miter rail component since the previous inspection.

(4) When defects are detected, the inspector shall take the necessary <u>remedial action</u> as specified in this manual and in accordance with Part I, §213.5 and §213.5(MR).

## Subpart E(MR) — Inspection Procedures by Type

### §213.233(MR) Specific Inspection Procedures

The following paragraphs give specific procedures for the inspection of the various types of miter rails and expansion joints found on the Amtrak system. These procedures are in addition to the basic procedures found in §213.232(MR).

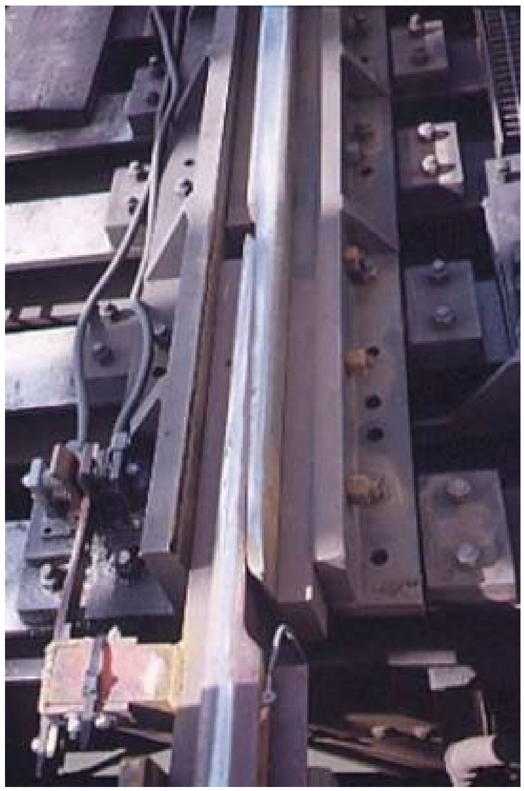
| MOVABLE BRIDGES | | | | | |
|---|---|---|---|---|---|
| **Bridge** | **Interlocking** | **Milepost** | **Bridge Type** | **Miter Rail** | **Notes** |
| **New England Division** | | | | | |
| Mystic River | Mystic River | 131.9 | Swing | Long Point Steel (thick web) | |
| Thames River | Groton | 124.2 | Lift | Long Point Steel (thick web) | |
| Shaws Cove | Shaws Cove | 122.5 | Swing | Long Point Steel (thick web) | |
| Niantic | Nan | 116.7 | Bascule | Long Point Steel (thick web) | |
| Connecticut River | Conn | 106.8 | Bascule | Two-Piece Fabricated “Rider Rail” | |
| **New York Division** | | | | | |
| Portal | Portal | 6.3 | Swing | Long Point Steel (thick web) | |
| Dock | Dock | 8.5 | Lift | Two-Piece Fabricated “Rider Rail” | |
| Pelham Bay | Pelham Bay | 15.5 | Bascule | Two-Piece Fabricated “Rider Rail” | |
| Spuyten Duyvil | Inwood | 9.9 | Swing | Long Point Steel | |
| Rensselaer | CP LAB | 143.0 | Swing | Sliding Block | |
| **Mid Atlantic Division** | | | | | |
| Susquehanna River | Grace/Perry | 60.2 | Swing | None | Manually Locked |
| Bush River | Bush | 72.1 | Bascule | None | Manually Locked |
| **Central Division** | | | | | |
| Chicago | South Branch | 446.2 | Lift | Long Point Steel (thick web) | |
| Michigan City | Michigan City Drawbridge | 228.5 | Swing | Long Point Steel (thick web) | |

### §213.234(MR) Inspection of Long Point Type Miter Rails

(a) This miter rail design shall be inspected in accordance with §213.232(MR) and the following. These miter rails may be made of either rail steel or manganese steel.

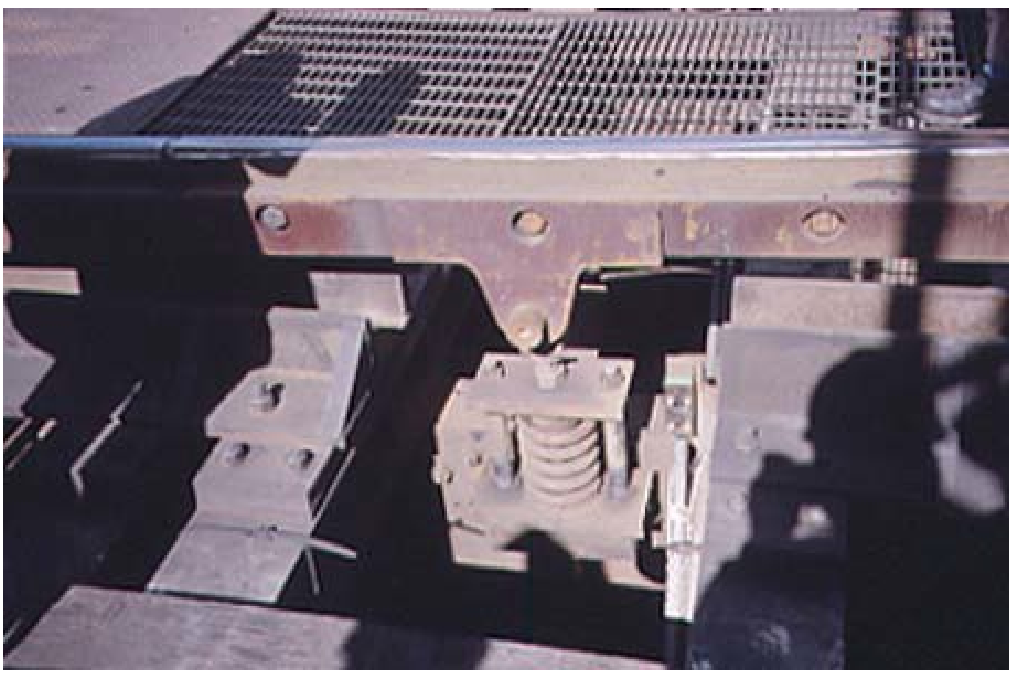
(b) This miter rail design is intended for use in tracks up through and including Class 5 on swing bridges. New designs of the long point miter rail may be made of rail steel and consist of one long rail without the heel joint. Elimination of the joint is accomplished by flash butt welding or the continuous rolling of the rail. The new design uses the long side bar to seat the lift rail in the bedplate. This side bar will not be considered a joint bar in the continuous rail design.

(c) The long point miter rail consists of two rolled manganese steel rails, mitered to match each other. The rails rest in base plates that provide both vertical support and lateral stability. The lift rail is raised vertically by a below-deck mechanical linkage system. This system lifts and flexes the lift rail assembly which is bolted to the adjacent standard tee rail. See the photographs below for illustrations of a long point miter rail in the closed and open positions.



**Closed Long Point Miter Rail**

**Open Long Point Miter Rail**



**Open Long Point Miter Rail**

There are two variations on the long point miter rail design, Type A and Type B. While they are similar, parts are not interchangeable.

**§213.234.1(MR) Side Bars at Heel of Miter Rails (Both Approach and Lift Assemblies)**

(a) With the miter rail in the up position, wire brush plates, side bars, and bolts wherever required to allow for a thorough visual inspection.
(b) Inspect for cracks and loose or missing bolts.
(c) Tighten loose bolts. Replace missing or ineffective bolts with a bolt of the proper

diameter and length. Replacement bolts must be of the proper length and diameter so as not to interfere with movement of the miter rail. Replacement bolt assemblies at the point area may require grinding to allow for proper seating of the lift rail. Bolts shall be ground flush with the side bars or mating surface.

(d) Each joint at the heel of the miter rail must have two bolts in each side of the joint.

  (1) If fewer than four bolts are found, track speed is reduced to Class 1: 10 MPH (F) and 15 MPH (P).

  (2) If one rail end is unbolted, each movement over the miter rail shall be visually supervised by a person qualified under Part I, §213.7 at walking speed (not exceeding 4 MPH).

(e) If one bar is cracked less than 1/2", no speed restriction is required. Monitor at each inspection.

(f) If one bar is cracked 1/2" to 3", maximum speed shall be 25 MPH (F) and 30 MPH (P).

(g) If one bar is cracked greater than 3", it shall be treated as a broken bar.

(h) If both bars are cracked, maximum speed shall be 10 MPH (F) and 15 MPH (P).

  (1) Inspect before and after each bridge opening.

  (2) Bars must be replaced within seven days.

  (3) If the cracks are located in the joint heel area of the approach rail assembly, safety straps shall be applied as an approved repair.

(i) If one bar is broken or both bars are broken, and the lift rail joint connection is still held in place by at least two bolts between the breaks:

  (1) Each movement over the miter rail shall be visually supervised by a person qualified under Part I, §213.7 at walking speed (not exceeding 4 MPH).

  (2) Inspect before and after each bridge opening.

  (3) Lift rail assembly must be replaced within two days.

(j) If both bars are broken opposite each other:

  (1) Take bridge out of service for marine use (opening of bridge is prohibited).

  (2) Each movement over the miter rail shall be visually supervised by a person qualified under Part I, §213.7 at a walking speed (not exceeding 4 MPH).

  (3) Lift rail assembly must be replaced within one day.

(k) When a crack up to 1" in length located in the long side bar to "D" bar is detected and runs along the weld parallel to the running rail, it should be monitored at every inspection.

(l) If a long side bar to "D" bar weld crack is greater than 1" in length running parallel to the running rail, or if a crack progressed perpendicular to the running rail is greater than 1/2", a 15 MPH restriction shall be placed. The crack shall be monitored after each train movement until safety straps are applied to the approach rail or the lift rail assembly is replaced.

(m) The above side bar restriction is only applicable when the side bars are used as a joint connecting two running rails. Any side bars that are used only as a bedplate guide and spacer and do not connect two running rails are not subject to the above restriction.

(n) Welding of any structural cracks found in long side bars is prohibited.

**§213.234.2(MR) Mitered Point Rails and Joints**

(a) Point rails must be seated properly.

(b) Remove any obstructions and clean the area of any obstruction that may interfere with proper rail seating.

(c) Tighten any loose bolts that may interfere with the movement of lift rail assemblies. During tightening, observe the head of all countersunk bolts to ensure that they are seated properly. No part of a bolt head, thread, or nut may extend beyond the vertical face of the side bar. Replace any stripped bolts.

(d) If any part of a bolt is found to extend out from the vertical face of a rail or side bar:

   (1) A person designated under Part I, §213.7 determines that the miter rail assembly is not obstructed, no restriction on track speed is required.

   (2) The miter rail must not be lifted for any reason until it has been determined that no damage to the track structure will occur during either opening or closing.

(e) If a bolt is stripped, or for any reason cannot be tightened, it must be replaced.

(f) If rail ends are mismatched this could indicate other problems. Inspect hinge joint bolts, check for proper torque and thoroughly inspect area until the cause is found and necessary remedial action taken to eliminate rail end mismatch.

(g) With miter joints in the closed position, inspect for vertical and gage line mismatch at the miter. Confirm compliance with Part I, §213.115 and §213.53(MR).

(h) Inspect rail for surface defects, cracks or breaks in compliance with §213.113(MR) and other applicable sections of this part as well as Part I, §213.113.

(i) Inspect the rails for metal flow and, if found, remove by grinding within seven days.

**§213.234.4(MR) Heel Ends of Fixed and Movable Points**

(a) Check for metal flow; if found, schedule for grinding within seven days.

(b) Inspect for any misalignment of the rail heads and compliance with Part I, §213.115 and §213.115(MR). If mismatch is detected, take appropriate remedial action and correct within seven days.

**§213.234.5(MR) Overall Point and Sidebar Assembly**

Twice a year, ultrasonically test mitered point rails and side- bars for internal defects. If defects are detected, take appropriate measures.

**§213.234.6(MR) Bedplates**

(a) Bedplates must be securely fastened to all timbers or steel ties. If the distance between effective fastenings is more than 48", the maximum train speed permitted is 25 MPH (F) and 30 MPH (P).

(b) Inspect for loose fasteners. Tighten or replace as required.

(c) Remove any obstructions that may interfere with the rail sitting squarely and uniformly on the bedplates.

(d) Wire brush and clean bedplate area thoroughly.

(e) Visually inspect mating surfaces for cracks and/or excessive wear.

(f) Check bedplates and welds for cracks.

(g) All cracks or breaks must be repaired within five days of detection. Center punch and monitor the growth of all cracks. Until repairs are made, impose speed restrictions, if applicable, as follows:

| Weld Crack Size | Speed Restrictions |
|---|---|
| Any longitudinal crack less than 4" in total length. Any gusset plate crack less than 1". | No restriction. Re-examine during every inspection until repaired. |
| Any longitudinal crack between 4" and 10" or less or equal to 25% of weld length. Any gusset plate crack greater than 1" but less than or equal to 25% of total gusset to bedplate or gusset to vertical guide bar weld length. (See Example 1, below) | Maximum speed 25 MPH (F) and 30 MPH (P). Schedule for repair and inspect daily until repaired |
| A longitudinal crack more than 25% of weld bead length or more than 10", whichever is less. Any gusset plate crack greater than 25% of the total gusset to bedplate or gusset to vertical guide bar weld length. (See Example 2, below.) | Each operation over the miter rail shall be visually supervised at walking speed (not exceeding 4 MPH). |

*Example 1*. Weld bead is 24" long and is cracked for a length of 5". As 5" is 21% of the weld length but is less than 10", impose 25 MPH (F) and 30 MPH (P) restriction until repaired.

*Example 2*. Weld bead is 48" long and is cracked for 11". 11" is only about 23% of the bead length but is greater than 10", therefore impose supervised walking speed (not exceeding 4 MPH) restriction until repaired.

| Bedplate Crack Size Other than at Weld | Speed Restrictions |
|---|---|
| Any bedplate crack less than 5" in total length. Any gusset plate crack less than 1". | No restriction. |
| Any bedplate crack 5" to 10" in length. Any gusset plate crack between 1" and 2" in length. | Maximum speed 25 MPH (F) and 30 MPH (P). Inspect daily until repaired |
| Any bedplate crack greater than 10" in length. Any gusset plate crack greater than 2" in length. | Each operation over the miter rail shall be visually supervised at walking speed (not exceeding 4 MPH). |

**§213.234.7(MR) Lifting Lug**

(a) Check for cracks that initiate around the lug hole or lug body. If any cracks are found, maximum train speed is restricted to 10 MPH (F) and 15 MPH (P) until sidebar is replaced.

(b) Component must be replaced within 30 days.

### §213.234.8(MR) Retainer Screw

(a) Inspect to see if screw is loose, cracked, or broken.

(b) If screw is loose, tighten.

(c) If screw is cracked or broken, or if the screw is missing, impose restrictions as follows:

| Condition | Speed Restrictions |
|---|---|
| One cracked, broken or missing retainer screw per bar | Maximum speed 10 MPH (F) and 15 MPH (P) |
| Two cracked, broken or missing screws per bar | Visually supervise each operation over the rail at walking speed (not exceeding 4 MPH). |

(d) All cracked, broken, or missing screws must be replaced within 24 hours of inspection.

### §213.234.9(MR) Retainer Bar

(a) Check to see if bar is missing, cracked or broken.

(b) If defective in any manner, replace within 24 hours of inspection.

(c) In a design with one retainer bar, if the bar is broken or missing then each train movement over the miter rail shall be visually supervised at walking speed (not exceeding 4 MPH).

(d) If all retainer bars in an assembly are either broken or missing and if replacement cannot be made immediately, each train movement over the miter rail shall be visually supervised at walking speed (not exceeding 4 MPH). Note: Assemblies either have one or two retainer bars by design.

### §213.234.10(MR) Lift Lug Pin

(a) Verify that the lift lug pin is in place. Inspect visible surfaces of pin for cracks or breaks.

(b) If the pin is missing or if any cracks or breaks are found, and replacement cannot be made immediately, each movement over the miter rail must be supervised at walking speed (not exceeding 4 MPH). If the pin is missing, the miter rail shall not be operated except under the visual supervision of a qualified B&B employee.

(c) Defective lift lug pins must be replaced within 24 hours of inspection.

(d) The B&B Department shall remove all pins for a detailed inspection a least once a year.

### §213.234.11(MR) Rail Lifting Assembly

***NOTE: THIS IS A BRIDGE & BUILDING DEPARTMENT APPLIANCE. IF IT IS FOUND TO BE DEFECTIVE, PROTECT THE TRACK AND THEN NOTIFY B&B FOR REPAIRS.***

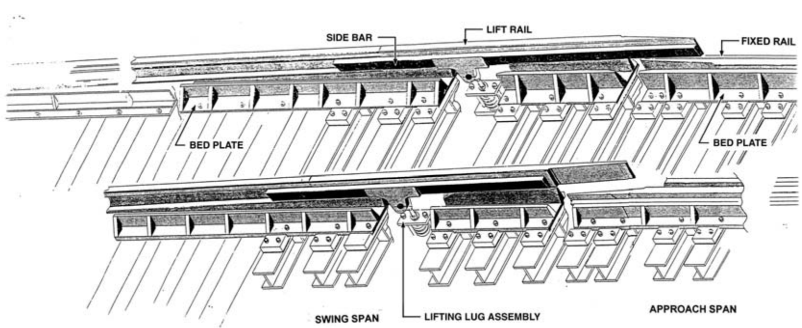
(a) Inspect entire assembly for cracks, breaks, or unusual wear.

(b) If any failure is detected, impose restrictions as follows:

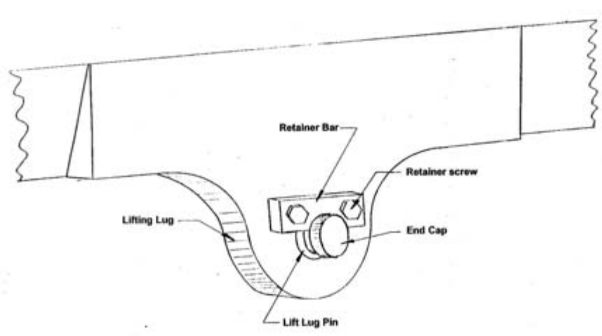
| Condition | Restrictions/Actions |
|---|---|
| Any crack, loose bolt or other threaded fastener element. | Maximum speed, 30 MPH (F)/45 MPH (P), with constant observation by qualified B&B employee until repaired. |
| Any broken or bent assembly component. | Maximum speed 10 MPH (F)/15 MPH (P) with constant observation by qualified B&B employee until repaired. Miter rail shall not be operated except under the supervision of a qualified B&B employee. |

### §213.234.12(MR) Drawings

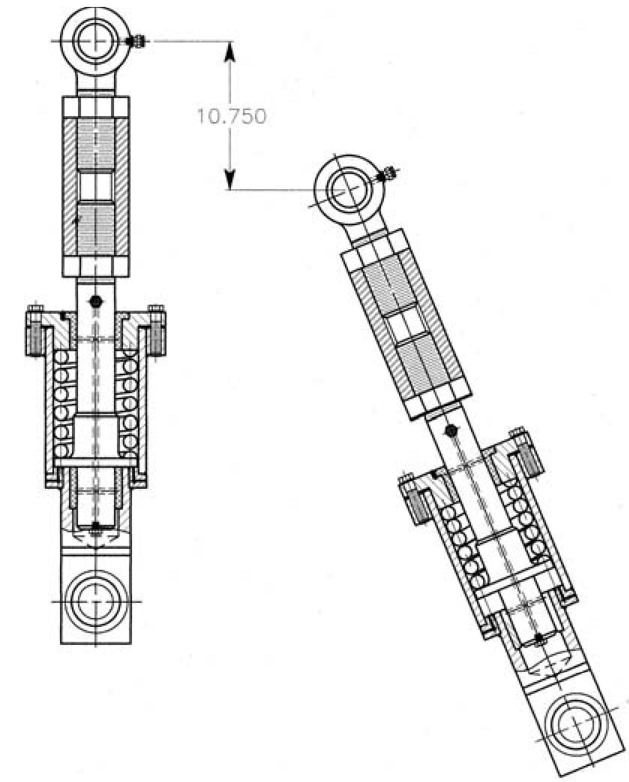
See attached drawings for locations of components described above.



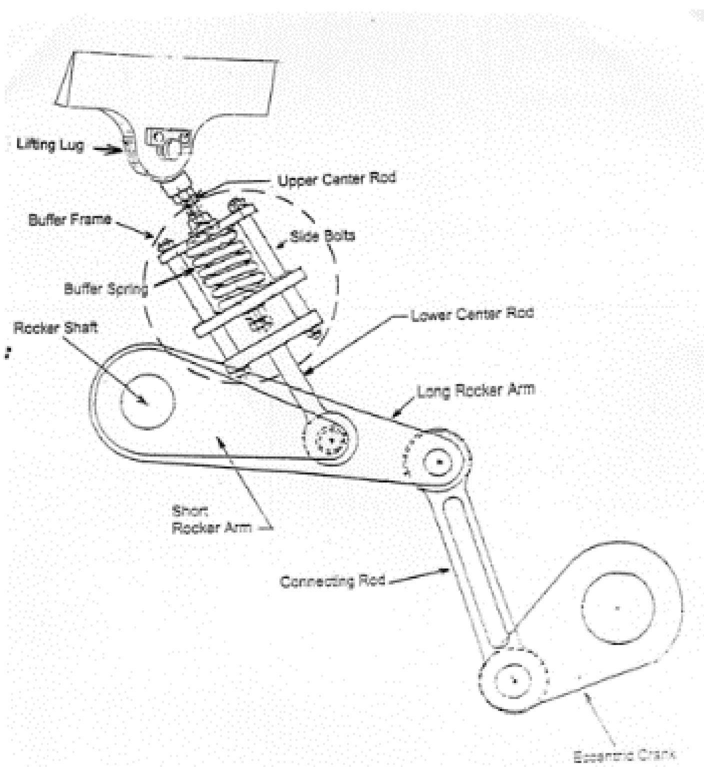

**Long Point Miter Rail**




**Lift Lug Assembly**




**Miter Rail Operator**




**Rail Lifting Assembly**

**Miter Rail Operator on the Underside of a Long Point  Miter Rail**

## §213.235(MR) Inspection of Three-Piece Manganese Steel Type Miter Joints

(a) Three-piece manganese steel type miter rails shall be inspected in accordance with §213.232(MR) and the following.

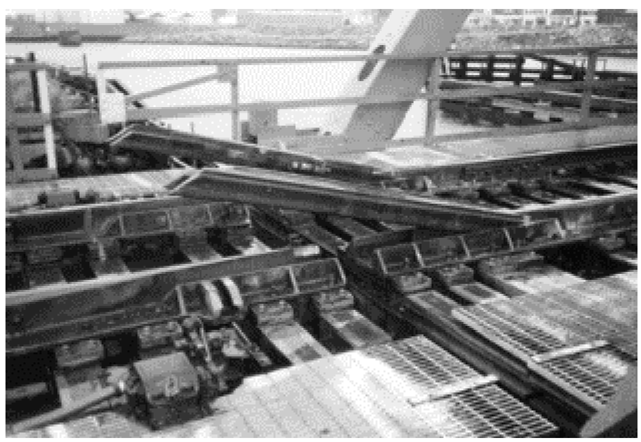
(b) This miter rail design is used on some swing bridges and consists of three solid manganese steel castings as illustrated in §213.235.9(MR).

(c) The principal components of the three-piece miter rail are cast manganese steel. It basically works as follows:

   (1) Rigid point assemblies are fastened to both the fixed span and the moving span.

   (2) A rocker rail is placed between the rigid point assemblies to bridge the gap between the movable bridge span and the fixed span.

   (3) The movable span end of the rocker rail is hinged and attached to the movable span point assembly and to a mechanical linkage on the movable bridge span. The connection to this linkage can either pull down or push up on the rocker rail, causing it to pivot about the hinge pin and either open or close relative to the fixed-point assembly. The photograph below shows a typical three-piece manganese steel miter rail in the open position.



**Open Three-Piece Manganese Steel Type Miter Rail**

Because the three-piece manganese steel miter rail assembly includes two mitered surfaces as well as two glued joints to connect it with adjoining standard tee rail, all within a short distance, it is not suitable for track operation at speeds above Track Class 3.

## §213.235.1(MR) Manganese Steel Castings – General

Thoroughly examine castings for cracks or other structurally significant defects. Clean castings as required to properly view all surfaces, including removal of all grease and debris from flangeway area. If cracks are found to exist in manganese casting, take action as specified in the table below:

| Casting Crack Size | Speed Restrictions |
|---|---|
| Vertical cracks up from base 1/2" or less | No operating restriction. Center punch and monitor. |
| Vertical cracks up from base greater than 1/2" | Maximum speed 10 MPH (F)/ 15 MPH (P) until repaired or replaced. |
| Vertical cracks 1/2" or less originating in casting from running surface | Maximum speed 25 MPH (F)/ 30 MPH (P). Center punch and monitor. Repair within 48 hours. |
| Vertical cracks greater than 1/2" originating in casting from running surface | Train operation restricted to walking speed (not exceeding 4 MPH) under the supervision of a person qualified under Part I, §213.7 until repaired. |
| Any other crack less than or equal to 2" | No operating restrictions. Center punch and monitor. |
| Any other crack greater than 2" but less than 5" | No operating restrictions. Repair within seven days. |
| Any other crack 5" to 8" | Maximum speed 25 MPH (F) and 30 MPH (P). Repair within seven days and inspect daily until repaired |
| Any other crack greater than 8" | Each operation shall be visually supervised at walking speed (not exceeding 4 MPH). |

**§213.235.2(MR) Rail Joint Between Rocker Rail and Fixed Rail**

(a) The gap between the rocker rail and the fixed rail on the land-side approach to the miter joint should be no less than 1" and no more than 7" measured parallel to the gage line. Rail end gaps outside these limits will require adjustment within seven days. No restriction necessary.

(b) The gap between rail ends shall be free from any metal flow. If any metal flow is present, grind within 48 hours.

**§213.235.3(MR) Manganese Fixed Points**

(a) Inspect for cracks/breaks.

(b) If a point is worn or broken out more than 5/8" down and 6" back, maximum speed is 10 MPH until repairs are made. Components may be repaired in track by a qualified welder by building up manganese steel casting with weld material.

(c) Manganese fixed points showing vertical cracks of 2" or more must be removed from track prior to welding. If tip is found to be worn or broken out more than 3/4" down, the maximum speed is 10 MPH.

(d) All fixed points with cracks in excess of 2" must be removed from track and repaired in an approved welding shop.

### §213.235.4(MR) Manganese Rocker

(a) Examine rocker for signs of wear or cracks.

(b) If running surface is worn or broken out more than 3/8", limit speed to 10 MPH.

(c) All grease and debris must be thoroughly removed from flangeway area to locate and determine the extent of any cracking.

### §213.235.5(MR) Manganese Steel Cradle

(a) Remove any obstruction that would prevent manganese rocker from full seating on manganese cradle.

(b) Examine cradle for cracks or excessive wear. If running surface is worn or broken out more than 3/8" the maximum speed is 10 MPH until repaired or replaced.

### §213.235.6(MR) Hinge Pins

(a) Inspect for wear on the pin bolt and for worn or loose spring washer and security nut. If any wear is greater than 1/8", replace bolt. Until component is replaced, the maximum speed is 10 MPH (F)/15 MPH (P).

(b) Defective components must be replaced within seven days.

### §213.235.7(MR) Lift Lugs

(a) Examine the lifting lugs on the heel of the manganese steel rocker. Check for cracks that initiate around the lug hole or lug body.

(b) If either lug is cracked, maximum speed is 10 MPH (F)/ 15 MPH (P) and the component must be replaced within seven days.

### §213.235.8(MR) Rail Ends at Miter Joints

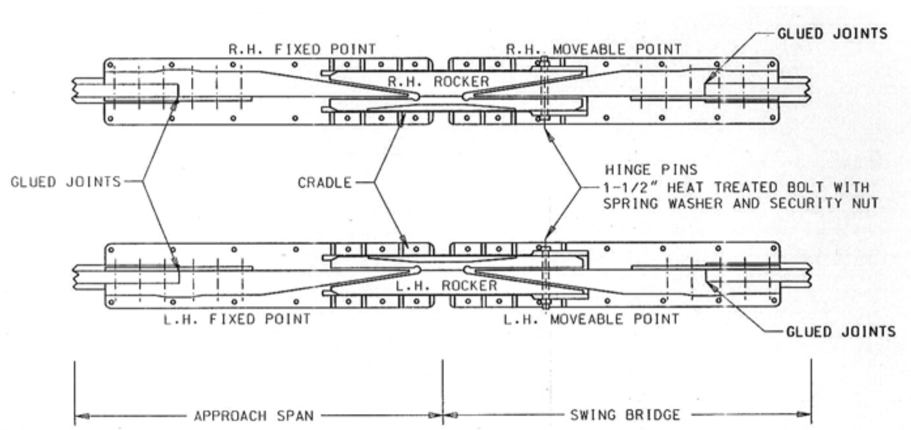
(a) If rail ends are mismatched this could indicate other problems. Inspect hinge joint bolts, check for proper torque and thoroughly inspect area until the cause is found and necessary remedial action taken.

(b) With miter joints in the closed position, visually inspect for vertical and gage line mismatch at the miter. Confirm compliance with §213.115(MR).

(c) Inspect rail for surface defects, cracks or breaks in compliance with §213.113(MR) and other applicable sections of this part as well as Part I, §213.113.

(d) Visually inspect the rails for metal flow and, if found, remove by grinding within 7 days.

### §213.235.9(MR) Drawings




**Three-Piece Manganese Steel Miter Rail**

## §213.236(MR) Inspection of Two-Piece Manganese Steel Type Miter Joint

(a) Two-piece manganese steel type miter rails shall be inspected in accordance with §213.232(MR) and the following.

(b) This miter rail design is used on both bascule and vertical lift bridges. Each miter rail consists of two solid manganese steel castings. Unlike the three-piece manganese steel miter rail assembly, the two-piece manganese steel design has no mechanical parts itself since the moving bridge superstructure provides all of the movement required. Operation over two-piece manganese steel type miter rails is restricted to Class 3 speeds or lower. A typical two-piece manganese steel miter rail is illustrated in the photographs below.

**Closed Two-Piece Manganese Steel Miter Rail**

**Open Two-Piece Manganese Steel Miter Rail**

### §213.236.1(MR) Manganese Steel Castings – General

Thoroughly examine castings for cracks or other structurally significant defects. Clean castings as required to properly view all surfaces, including removal of all grease and debris from flangeway area. If cracks are found to exist in manganese casting, take action as specified in the table below:

| Casting Crack Size | Speed Restrictions |
|---|---|
| Vertical cracks up from base 1/2" or less | No operating restriction. Center punch and monitor. |
| Vertical cracks up from base greater than 1/2" | Maximum speed 10 MPH (F)/ 15 MPH (P) until repaired or replaced. |
| Vertical cracks 1/2" or less originating in casting from running surface | Maximum speed 25 MPH (F)/ 30 MPH (P). Center punch and monitor. Repair within 48 hours. |
| Vertical cracks greater than 1/2" originating in casting from running surface | Train operation restricted to walking speed (not exceeding 4 MPH) under the supervision of a person qualified under Part I, §213.7 until repaired. |
| Any other crack less than or equal to 2" | No operating restrictions. Center punch and monitor. |
| Any other crack greater than 2" but less than 5" | No operating restrictions. Repair within seven days. |
| Any other crack 5" to 8" | Maximum speed 30 MPH (P) and 25 MPH (F). Repair within seven days and inspect daily until repaired. |
| Any other crack greater than 8" in length | Each operation shall be visually supervised at walking speed (not exceeding 4 MPH). |

### §213.236.2(MR) Miter Points and Joints

(a) Gap between fixed and moveable rails shall be no less than 1" and no more than 7" measured parallel to the gage line. Rail end gaps outside these limits will require adjustment within seven days. No restriction necessary.

(b) Gap between rail ends shall be free from any metal flow. If any metal flow is present, grind within 48 hours.

(c) If rail ends are mismatched, this could indicate other problems. Inspect hinge joint bolts, check for proper torque and thoroughly inspect area until the cause is found, and necessary remedial action taken.

(d) With miter joints in the closed position, inspect for vertical and gage line mismatch at the miter. Confirm compliance with Part I, §213.115 and §213.115(MR).

(e) Inspect rail surface defects, cracks or breaks in compliance with §213.113(MR) and other applicable sections of this part as well as Part I, §213.113.

(f) Visually inspect the rails for metal flow and, if found, remove by grinding within seven days.

(g) Inspect for cracks/breaks.

(h) If point is worn or broken out more than 5/8" down and 6" back, maximum speed is 10 MPH until repairs are made. Components may be repaired in track by a qualified welder by building up manganese steel casting with weld material.

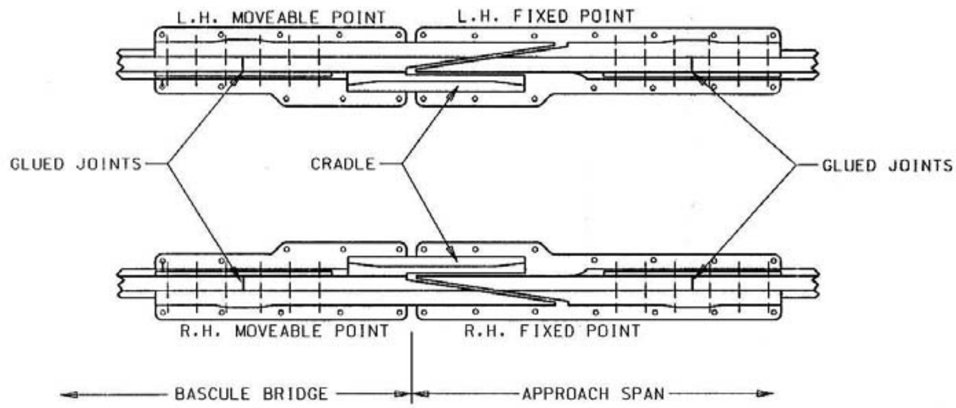
(i) Manganese tips showing vertical cracks must be removed from track prior to welding. If tip is found to be worn or broken out more than 3/4" down, the maximum speed is 10 MPH until replaced.

(j) All crack repairs must be made in an approved welding shop.

### §213.236.4(MR) Cradle Area

Examine base of cradle on fixed rail for cracks. All cracks must be repaired within seven days.

### §213.236.5(MR) Drawings




**Two-Piece Manganese Steel Miter Rail**

### §213.237(MR) Inspection of Two-Piece Fabricated "Rider Rail" Type Miter Joints

(a) Two-piece fabricated type miter rails shall be inspected in accordance with §213.232(MR) and the following.

(b) This design is used on bascule and vertical lift bridges. In this miter rail design, the ends of the abutting rails are cut square rather than being mitered (beveled) to overlap each other. Instead, the wheels are carried over the open gap by a "rider rail" that is positioned on the field side of the running rails where it can support the outside portion of the wheel tread. A typical two-piece fabricated rider rail assembly is shown in the photograph below.


**Two-Piece Fabricated "Rider Rail"**

### §213.237.1(MR) End Joints and Rail Joint Between Moveable and Fixed Rail

(a) The gap between fixed and moveable rails should be no less than 1" and no more than 4" measured parallel to the gage line. Rail end gaps outside these limits will require adjustment within seven days. No restriction is necessary.

(b) The gap between rail ends and the wheel riser shall be free from any metal flow. If found, grind within 48 hours.

(c) If rail ends are mismatched, this could indicate other problems. Inspect hinge joint bolts, check for proper torque and thoroughly inspect area until the cause is found and necessary remedial action taken.

(d) With miter joints in the closed position, visually inspect for vertical and gage line mismatch at the miter. Confirm compliance with Part I, §213.115 and §213.115(MR).

(e) Inspect rail for surface defects, cracks or breaks in compliance with §213.113(MR) and other applicable sections of this part as well as Part I, §213.113.

(f) Visually inspect the rails for metal flow and, if found, remove by grinding within seven days.

### §213.237.2(MR) Rider Rail (Wheel Riser)

Inspect rider rail (wheel riser) for wear. If riser is worn down more than 1/8" below the existing running rails, operating speed may not be more than 10 MPH. Repairs must be made in 48 hours.

### §213.237.3(MR) Angle Brackets

(a) Check angle brackets for any cracks in fillets.

(b) Any bracket with a crack longer than 3" shall be considered defective. All cracks or breaks, regardless of length, must be repaired within 30 days.

  (1) Any crack less than 3", punch mark and monitor.

  (2) If one of the two brackets closest to the mitered end is defective, train speed is limited to a maximum of 25 MPH (F)/30 MPH (P).

  (3) If both brackets closest to the mitered end are defective, operations are restricted to walking speed (not exceeding 4 MPH) with visual supervision of each move over miter joint by a person qualified under Part I, §213.7.

(c) Replace all defective angle brackets within 30 days.

### §213.237.4(MR) Bedplate

(a) Observe bedplate for vertical movement between the top of tie and the bottom of plate during opening and closing. Vertical movement may be a sign of missing or loose lag screws, hook bolts, spring washers or deteriorated headblock ties. Limit speed as follows:

| | |
|---|---|
| 1/8” | 60 MPH (F) / 80 MPH (P) |
| 3/16” | 40 MPH (F) / 60 MPH (P) |
| 1/4" | 10 MPH (F) / 15 MPH (P) |

(b) Bedplates must be securely fastened to all timbers or steel ties. If the distance between effective fastenings is more than 48", the maximum train speed permitted is 25 MPH (F) and 30 MPH (P).

(c) Inspect for loose fasteners; tighten or replace as required.

(d) Remove any obstructions that may interfere with the rail sitting squarely and uniformly on the bedplates.
(e) Wire brush and clean area thoroughly.
(f) Visually inspect mating surfaces for cracks and/or excessive wear.
(g) Check plates and welds for cracks.
(h) All cracks or breaks must be repaired within five days of detection. Center punch and monitor the growth of all cracks. Until repairs are made, impose speed restrictions, if applicable, as follows:

| Weld Crack or Break Size | Speed Restrictions |
|---|---|
| Any crack less than 1" in total length. This includes gussets. | No restriction. Re-examine during every inspection until repaired. |
| Any longitudinal crack between 1" and 7" or less than 25% of weld length. Any gusset plate crack greater than 1" but less than 25% of total gusset to bedplate or gusset to vertical guide bar weld length. (See Example 1, below.) | Maximum speed 25 MPH (F) and 30 MPH (P). Schedule for repair and inspect daily until repaired. |
| More than 25% of weld bead length or more than 7", whichever is less. Any gusset plate crack greater than 25% of the total gusset to bedplate or gusset to vertical guide bar weld length. (See Example 2, below.) | Each operation over the miter rail shall be visually supervised at walking speed (not exceeding 4 MPH). |

*Example 1*. Weld bead is 20" long and is cracked for a length of 4". As 4" is 20% of the weld length but is less than 7", impose 30 MPH
(P) speed restriction and inspect daily until repaired.

*Example 2*. Weld bead is 36" long and is cracked for 8". 8" is only about 22% of the bead length but is greater than 7", therefore impose supervised walking speed (not exceeding 4 MPH) until repaired.

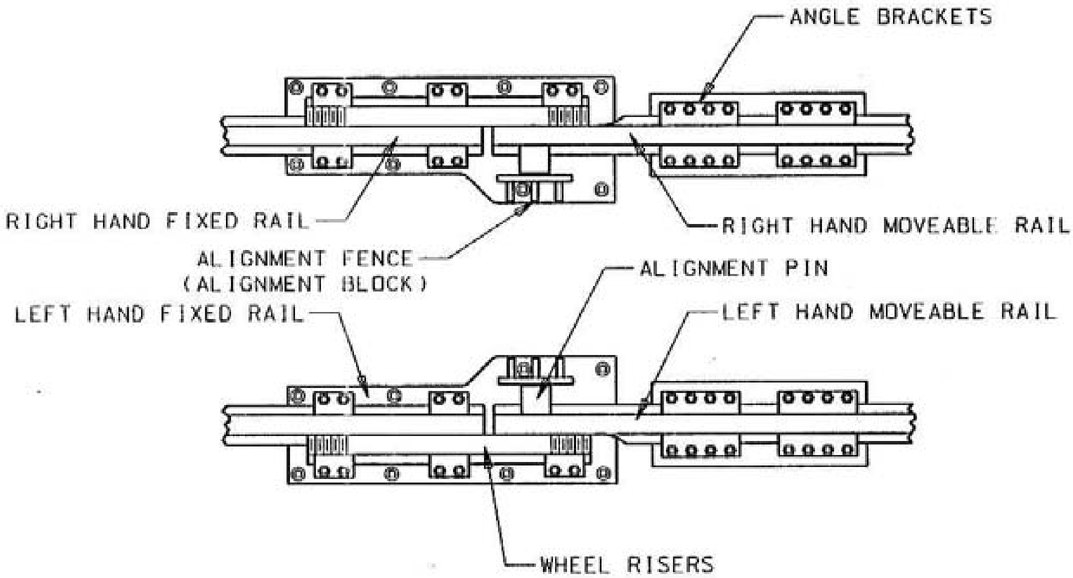
| Bedplate Crack Size Other than at Weld | Speed Restrictions |
|---|---|
| Any bedplate crack less than 5". | No restriction. |
| Any bedplate crack 5" to 7" in length. Any gusset plate crack between 1" and 2". | Maximum speed 25 MPH (F) and 30 MPH (P). |
| Any bedplate crack greater than 7" in length. Any gusset plate crack greater than 2". | Each operation over the miter rail shall be visually supervised at walking speed (not exceeding 4 MPH). |

**§213.237.5(MR) Rail Clips**

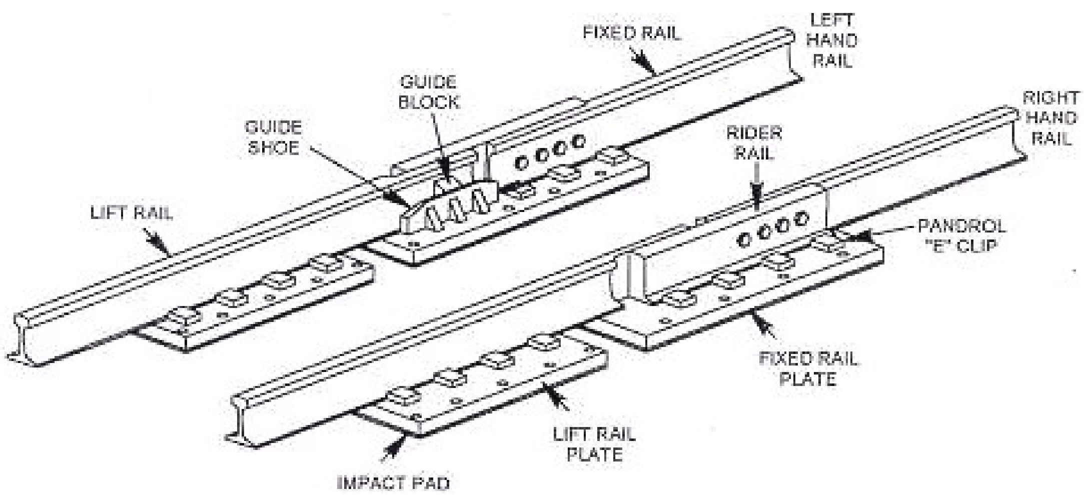
(a) Inspect for loose or missing bolts/washers. Replace or tighten as required.
(b) If rail clip is cracked, broken, or missing and until repaired:
   (1) One clip - replace within seven days, no restriction
   (2) Two clips - maximum speed is 25 MPH (F)/30 MPH (P)
   (3) More than two clips - walking speed (not more than 4 MPH) until replaced

### §213.237.6(MR) Drawings

See attached drawings for locations of components described above.




**Two-Piece Fabricated "Rider Rail" (Old Style)**




**Two-Piece Fabricated "Rider Rail" (New Style)**

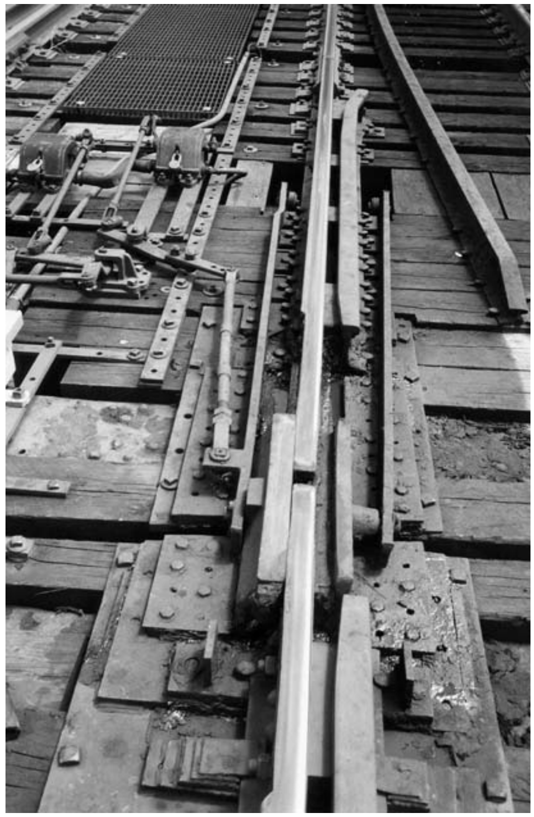
### §213.239(MR) Inspection of Sliding Block Type Miter Rail Joint

(a) Sliding block type miter rails shall be inspected in accordance with §213.232(MR) and the following.

(b) In this design, the ends of the rails are cut square, rather than mitered. The sliding block is a piece of machined steel that effectively wraps around the web and base of the two rails, forming a continuous rail joint across the gap. The outside rider rail on top of the field side of the sliding block carries the wheels over the requisite gap between the fixed rail and the moveable rail.

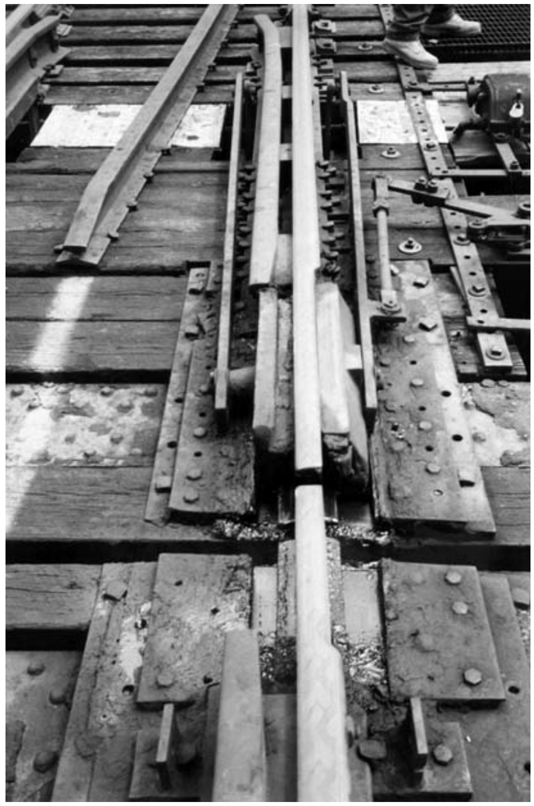
(c) When the bridge is to be opened, the sliding block is moved longitudinally on the fixed rail until the moveable rail is free. The bridge can then be opened.

(d) The sliding block design is restricted to tracks operating at speeds allowed for Track Class 2 and lower.



**Closed Sliding Block Type Miter Joint**

**Closed Sliding Block Assembly**



**Open Sliding Block Type Miter Joint**

### §213.239.1(MR) Cotter Pins

Inspect for broken or missing pins and replace as required.

### §213.239.2(MR) Locking Keys

(a) Inspect and if found to be broken or missing, comply with the following until replacement can be made:

(1) One missing or broken - no restriction, replace within 30 days.

(2) Two missing or broken - maximum speed is 10 MPH (F)/15 MPH (P) with each move over joint visually supervised by a person qualified under Part I, §213.7 until replaced.

### §213.239.3(MR) Wheel Riser (Wearing Strip)

Inspect wheel riser for wear. If riser is worn down more than 1/8" below the running rail's original contour, operating speed over that riser may not be more than 10 MPH (F) (P). Repairs must be made within 48 hours.

### §213.239.4(MR) Base Plates and Casting

Inspect for cracks, breaks and unusual wear or gouging. If worn or gouged - schedule for repair, no restriction. All cracks must be repaired within five days of detection. Center punch and monitor the growth of all cracks. Until repairs are made, impose a speed restriction, if applicable, as follows:

| Baseplate or Casting Crack Size | Speed Restrictions |
|---|---|
| Any crack less than 5" | No restriction. |
| Any cracks 5" to 7" | Maximum speed 10 MPH (F) and 15 MPH (P). Inspect daily until repaired. |
| Any cracks greater than 7" | Each operation over the miter rail shall be visually supervised at walking speed (not exceeding 4 MPH). |

**§213.239.5(MR) Rail Lock Block**

(a) Inspect for cracks originating from inside corners at base of rail. If cracks are found and length is under 6", no restriction; punch mark and schedule replacement. If length is over 6", maximum speed is 10 MPH (F)/ 15 MPH (P) until replaced.

(b) Defective rail lock block must be replaced within 30 days.

(c) Defective rail lock block may be repaired only at an approved welding facility. Field welding is prohibited.

**§213.239.6(MR) Operating Pins**

(a) Inspect for cracks or breaks.

(b) If any cracks or breaks are found, sliding block must be blocked in the closed position until replaced. Block may be opened and closed manually but must be inspected after each bridge opening.

(c) Operating pins requiring repairs must be removed and repaired in an approved machine shop.

**§213.239.7(MR) End Joints and Rail Joint Between Moveable and Fixed Rail**

(a) The gap between fixed and moveable rails should be no less than 1" and no more than 4". Rail end gaps outside these limits will require adjustment within 30 days. No restriction necessary.

(b) The gap between rail ends shall be free from any metal flow. If metal flow is found, grind within 48 hours.

(c) If rail ends are mismatched, this could indicate other problems. Inspect hinge joint bolts, check for proper torque and thoroughly inspect area until the cause is found and necessary remedial action taken.

(d) With miter joints in the closed position, visually inspect for vertical and gage line mismatch at the miter. Confirm compliance with Part I, §213.115 and §213.115(MR).

(e) Inspect rail for surface defects, cracks or breaks in compliance with Part I, §213.113 and §213.113(MR).

(f) Visually inspect the rails for metal flow and, if found, remove by grinding within seven days.

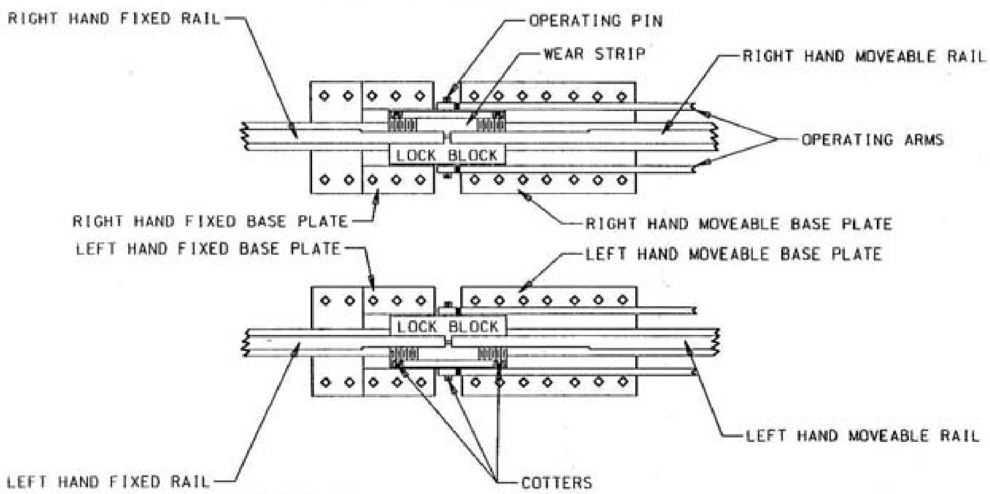
### §213.239.8(MR) Reinforcing Bars

(a) If bars are loose and three or fewer consecutive rivets are missing, no restriction required. Inspect after each bridge opening to ensure proper alignment of lock block.

(b) If bars are missing, maximum speed is 10 MPH (F)/ 15 MPH (P). Inspect after each bridge opening to ensure proper alignment of lock block. The bar must be replaced within 30 days.

### §213.239.9(MR) Drawings

See attached drawings for locations of components described above.




**Sliding Block Type Miter Rail**

**§213.240(MR) Inspection of Rail Expansion Joints**

(a) Rail expansion joints shall be inspected in accordance with §213.232(MR) and the following.

(b) It is very important that miter rail assemblies remain fixed relative to the bridge structures that they sit upon. In addition to being well-anchored to the bridge deck, the miter rails should not be subjected to high thermally induced forces from the adjacent rail. This is particularly true when the adjoining rails are continuously welded.

In order to prevent rail thermal stress from moving the miter rail assemblies, most movable bridges incorporate expansion joints in the fixed rail approaches to the miter joints. Typically a single stick of rail is placed between the expansion joint and the miter joint rail. The expansion joint relieves any thermally induced stress in the welded rail approaching the miter joint. Most expansion joints allow for rail movement in one direction only. The small amount of rail thermal stress that occurs between the miter rail and the sliding rail expansion joint can be handled by proper anchorage of the rails and the miter rail assembly to the bridge deck.

These items are sometimes called "sliding rail joints" since they function by allowing the rail on the land side of the expansion joint from the miter rail to slide back and forth depending on rail temperature. The photograph below illustrates a typical expansion joint.

**Sliding Rail Expansion Joint**

(c) Expansion joints are restricted to a maximum of Track Class 5 speed limits.

**§213.240.1(MR) Sliding Rail Assembly**

(a) Measure the gap at the top of the railheads between the full side of the sliding rail and the casting. The gap should be less than 1/16". Gaps up to 1/8" indicate the start of loose bolts, braces and blocks and will require adjustment within 24 hours. No restriction will be required. Gaps greater than 1/8" require immediate adjustment and if the bolts, braces and blocks are in place, a 25 MPH (F) and 30 MPH (P) restriction is required until repaired.

(b) The gap between side of the sliding rail and the casting shall be free from any metal flow. If any metal flow is present, grind within seven days.

(c) Inspect rail for surface defects, cracks or breaks in compliance with Part I, §213.113 and §213.113(MR).

(d) Visually inspect the rails for metal flow and, if found, remove by grinding within seven days.

**§213.240.2(MR) Point Area**

(a) Inspect for cracks/breaks.

(b) If a point is worn or broken out more than 5/8" down or 6" back, the component shall be replaced. Until replacement is made, maximum speed is 10 MPH. After removal, the point may be built up with manganese weld material in a shop by a qualified welder.

**§213.240.3(MR) Housing**

(a) Thoroughly examine manganese steel housing casting for cracks after removing all grease and debris from flangeway area. If cracks are found to exist in manganese casting:

| Housing Crack Size | Speed Restrictions |
|---|---|
| Vertical cracks up from base up to 1/2" | No restriction. Center punch and monitor. |
| Vertical cracks up from base greater than 1/2" | Restrict operating speed to 10 MPH (F)/15 MPH (P) until housing is replaced. |
| Vertical cracks 1/2" or less originating in casting from running surface | 25 MPH (F)/30 MPH (P). Center punch and monitor. Repair within 48 hours. |
| Vertical cracks greater than 1/2" originating in casting from running surface | Train operation shall be restricted to walking speed (not exceeding 4 MPH) under the supervision of a person qualified under Part I, §213.7 until repaired. |
| Any other crack less than or equal to 2" | No restriction. Center punch and monitor. |
| Any other crack greater than 2" but less than 5" | No restrictions. Repair within seven days. |
| Any other crack 5" to 8" | Maximum speed 30 MPH (P) and 25 MPH (F). Repair within seven days and inspect daily until repaired |
| Any other crack greater than 8" | Each operation over the miter rail shall be visually supervised at walking speed (not exceeding 4 MPH). |

(b) Manganese castings showing vertical cracks must be removed from track prior to welding. All repairs of vertical cracks must be made in an approved welding shop.

**§213.240.4(MR) Braces and Fastenings**

(a) Inspect for cracks and loose or missing bolts.

(b) If any bolts are loose, tighten. If any bolts are missing, replace with a bolt of the proper diameter and length.

**§213.240.5(MR) Heel and Toe Joints**

(a) Each joint at the heel of the rail expansion joint must have a minimum of two bolts on each side of the joint.

(b) If fewer than four bolts are found, track speed is reduced to Class 1: 10 MPH (F) and 15 MPH (P).

(c) If one rail end is unbolted, each operation over the expansion rail shall be visually supervised at walking speed (not exceeding 4 MPH).

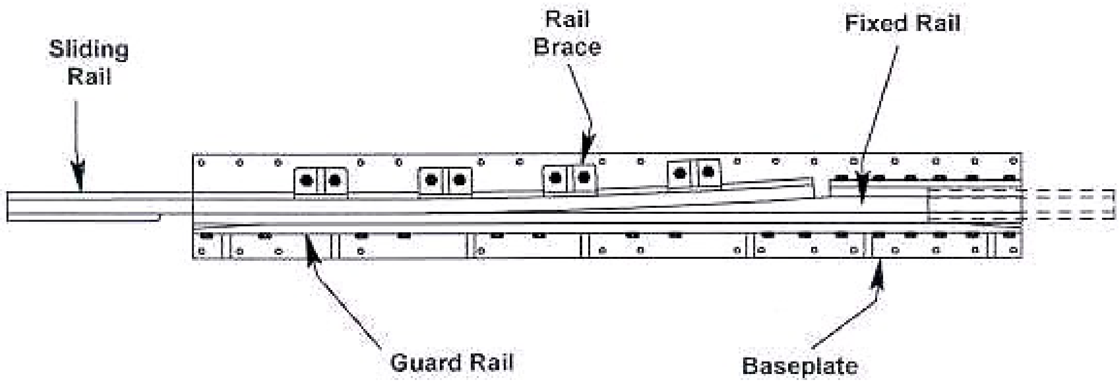
**§213.240.6(MR) Additional Requirements**

(a) Rail expansion joints must be installed and maintained in pairs and opposite each other with no stagger so that the guard rail of each can protect the point of the other.

(b) If a rail expansion joint must be removed from track, it must be replaced immediately. At no time shall a single rail expansion joint exist in track under traffic conditions without its mate.

**§213.240.7(MR) Drawings**

See drawing below for locations of components described above.




**Sliding Rail Expansion Joint**

## Subpart F(MR) — Inspection Records and Tools

### §213.241(MR) Inspection Records (FRA §213.235)

(a) Inspection records shall comply with the requirements of Part I, §213.241. The results of inspections of miter rails and expansion joints are to be made on the appropriate forms as described in this section.

### §213.242(MR) Inspection Responsibilities

(a) Track supervisors or a Division Officer shall review and approve all miter rail and expansion joint inspection reports for their territory.

(b) The designated inspectors and persons responsible for the sign off and review of inspections as prescribed in this manual are given in the following table:

| Miter Rail/Expansion Joint Inspection Responsibility | | |
|---|---|---|
| | Reporting Form | |
| | NRPC 1580 | NRPC 2880 |
| | Inspection Frequency | |
| **Responsible Person** | **Twice Weekly*** | **Monthly/Quarterly/ Special** |
| Track Foreman/Inspector | X | X |
| Track Supervisor | | X |
| Division Officer | | Y |

* Some specific inspection activities are conducted at less frequent intervals. See specific inspection procedures.

X Track Supervisor required at monthly and special inspections.

Y Division Officer required only on a quarterly basis.

### §213.250(MR) Tool Requirements

See Part I, §213.250 for typical tools used in track inspection.

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# SUBPARTS A-C

# LIMITS AND SPECIFICATIONS FOR MITER RAIL AND EXPANSION JOINT MAINTENANCE

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**LIMITS AND SPECIFICATIONS FOR MITER RAIL AND EXPANSION JOINT MAINTENANCE SUBPARTS A-C**
**Track Classes 1-5**

## Table of Contents

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## Subpart A(MRM) — General

### §1.0(MRM) Introduction

(a) This subpart is intended to provide employees with guidance as to recommended maintenance practices for miter rails and expansion joints.

(b) Engineering Practices and Procedures for miter rails/expansion joints are issued by the Deputy Chief Engineer-Track. Personnel that are designated to inspect and maintain miter rails and expansion joints shall strictly adhere to these directives. These directives shall remain in effect until such time that there is notification of a revision to, or cancellation of, the policy.

(c) Maintenance of miter rails and expansion joints must be performed in accordance with the specifications and limits given in this subpart and when applicable, the maintenance section of Part I.

### §2.0(MRM) Definitions

Miter rail and expansion joint definitions are included in Appendix A, Glossary.

### §3.0(MRM) Summary Information

There are presently several designs of miter rail systems in place. For information concerning the design used on a particular movable bridge structure, refer to the following table.

### §4.0(MRM) Movable Bridges

The following table lists the movable bridges and the types of miter rail equipment in place on each as of the date of this publication.

| MOVABLE BRIDGES | | | | | |
|---|---|---|---|---|---|
| **Bridge** | **Interlocking** | **Milepost** | **Bridge Type** | **Miter Rail** | **Notes** |
| **New England Division** | | | | | |
| Mystic River | Mystic River | 131.9 | Swing | Long Point Steel (thick web) | |
| Thames River | Groton | 124.2 | Lift | Long Point Steel (thick web) | |
| Shaws Cove | Shaws Cove | 122.5 | Swing | Long Point Steel (thick web) | |
| Niantic | Nan | 116.7 | Bascule | Long Point Steel (thick web) | |
| Connecticut River | Conn | 106.8 | Bascule | Two-Piece Fabricated “Rider Rail” | |
| **New York Division** | | | | | |
| Portal | Portal | 6.3 | Swing | Long Point Steel (thick web) | |
| Dock | Dock | 8.5 | Lift | Two-Piece Fabricated “Rider Rail” | |
| Pelham Bay | Pelham Bay | 15.5 | Bascule | Two-Piece Fabricated “Rider Rail” | |
| Spuyten Duyvil | Inwood | 9.9 | Swing | Long Point Steel | |
| Rensselaer | CP LAB | 143.0 | Swing | Sliding Block | |
| **Mid Atlantic Division** | | | | | |
| Susquehanna River | Grace/Perry | 60.2 | Swing | None | Manually Locked |
| Bush River | Bush | 72.1 | Bascule | None | Manually Locked |
| **Central Division** | | | | | |
| Chicago | South Branch | 446.2 | Lift | Long Point Steel (thick web) | |
| Michigan City | Michigan City Drawbridge | 228.5 | Swing | Long Point Steel (thick web) | |

### §7.0(MRM) Quality Control

(a) The person in charge of performing the maintenance activity or repair shall be responsible for the overall quality of the work performed.

(b) All maintenance work shall be performed in accordance with appropriate Engineering Practices, MW 1000, and Standard Track Plans

(c) The Track Supervisor and Assistant Division Engineer shall periodically review the work performed for quality, consistency, and adherence to Engineering Practice.

(d) Trackwork repairs that are deficient:

(1) May be cause for remedial action.

(2) Shall be brought to the attention of the local Track Supervisor.

(e) The Track Supervisor shall see that any additional work necessary is performed to bring the repair into compliance with Amtrak standards and procedures.

(f) The Track Supervisor shall be responsible to re-inspect substandard or deficient work to ensure that the corrective work is in compliance with Amtrak practice, procedures, and standards.

(g) Division Officers, along with the Track Supervisors and Foreman, are encouraged to make recommendations to the Division Engineer or Deputy Chief Engineer-Track as to required modifications to methods, procedures, and practices to improve the overall quality of work.

## Subpart B(MRM) — Maintenance Requirements

### §10.0(MRM) Introduction

(a) Miter rail and expansion joint systems shall be maintained to ensure acceptable performance at the track class speed designated for that section of railroad.

(b) All maintenance or repair work that is performed on miter rails and sliding rail expansion joints must be accomplished to ensure the safety and long-term performance of these assemblies. Maintenance limits given in this subpart supersede those found in the maintenance section of Part I. For example, when a repairable crack, identified in the safety section of Part II requires repair, the entire crack should be repaired. Maintenance repairs shall not be made just to meet the minimum requirements.

### §11.0(MRM) Responsibilities

Primary responsibility for maintenance of miter rails rests with the Track Department. Appliances attached to miter rails are the inspection and maintenance responsibilities of either the B&B or the C&S Departments. Whenever track maintenance work requires removal, replacement or adjustment of items attached to miter rails belonging to those departments, assistance shall be requested through the Division Engineer.

### §12.0(MRM) Maintenance

Track inspectors shall record on inspection reports where measured parameters indicate that miter rail is deteriorating, even though it is in compliance with existing track class. Where repair work is undertaken in the field, it shall be performed in strict accordance with applicable Engineering Practices.

### §12.1(MRM) Routine Maintenance

Routine maintenance consists of those activities, other than inspection, that shall be conducted on a regular basis without special scheduling. Examples of routine maintenance include:

(a) Lubrication of sliding and rotating surfaces.

(b) Tightening of threaded fasteners.

(c) Tightening/re-tightening of bolt assemblies and other threaded connections.

(d) Grinding to maintain original profile to reduce the possibility of premature welding or replacement.

(e) Other repairs to or replacement of components.

### §12.2(MRM) Remedial Action

Examples of such maintenance needs includes the following:

(a) Grinding of metal flow from miter rail and expansion joint assemblies together with their connecting rails. Maintaining the original contours of this special trackwork ensures the proper wheel/rail contact throughout the moveable bridge.

(b) Welding on wearing surfaces, when authorized.

(c) Shimming of fastener plates to restore surface.

(d) Adjustment of rail fastenings to restore gage and alignment.

(e) Major repair or replacement.

### §12.3(MRM) Restrictions

Corrective work may be accomplished either by repair of the defective component in the field or by replacement with an identical component known to be in acceptable condition, with the following exceptions:

(a) Field welding of any miter rail joint bar or sidebar is prohibited.

(b) Replacement of a defective item with non-identical material may be done only on an emergency basis. The correct material shall be installed within five days. A person qualified under Part I, §213.7 shall determine and impose appropriate operating restrictions until such time as the non-standard component can be replaced.

(c) If a sliding rail expansion joint must be removed and a replacement is not immediately available, a bolted rail may be installed. The sliding rail expansion joint in the other rail must also be replaced with a bolted rail at the same time. Protect the track with appropriate operating restrictions. Replace temporary bolted rails with sliding rail expansion joints within 30 days. Inspect daily until replaced and substitute a longer or shorter rail as required if the temporary rail appears to be experiencing extreme compressive or tensile stresses.

(d) Before sliding rail expansion joints are removed from track, the rail shall be anchored in accordance with Part I, §125(M). Temporary rails installed shall be solid box anchored.

## Subpart C(MRM) — Maintenance Limits

### §50.0(MRM) Scope of Subpart

Maintenance is repairing or replacing the component of a miter rail or expansion joint assembly. Maintenance limits are to be used as a triggering mechanism to prompt maintenance or reconstruction. It is Amtrak's policy to have a miter rail and expansion joint assembly that stays between construction and maintenance limits. As they break down, maintenance should be programmed before the assemblies reach the maintenance limits. Maintenance must be executed whenever the maintenance limits are exceeded and completed prior to reaching the safety limits. Whenever possible, miter rail and expansion joint assemblies should be repaired or reconstructed to construction limits.

### §53.0(MRM) Gage

(a) Gage is measured between the heads of rails at right angles to the rails in a plane 5/8" below the top of the rail head.

(b) Gage should be within the limits prescribed in the following table:

| Gage Maintenance Limits | | | |
|---|---|---|---|
| **Class of Track** | **Minimum (inches)** | **Maximum (inches)** | **Maximum Rate of Change per 31' (inches)** |
| 1-3 | 56-1/4 | 57-1/4 | 1/2 |
| 4 | 56-1/4 | 57-1/4 | 1/4 |
| 5 | 56-1/4 | 57 | 1/4 |

### §55.0(MRM) Alignment

Alignment should not deviate from tangent more than the amount prescribed in the following table:

| | **Alignment Maintenance Limits Tangent Track** |
|---|---|
| **Class of Track** | **The deviation of the mid-ordinate from a 62' chord[1] may not be more than (inches):** |
| 1-2 | 1 |
| 3 | 7/8 |
| 4 | 3/4 |
| 5 | 3/8 |

[1] The ends of the line or chord must be at points on the gage side of the line rail, 5/8" below the top of the rail head. Use line rail in accordance with Part I, §55.1(M).

### §63.0(MRM) Track Surface

(a) The surface of track should be maintained within the limits prescribed in the following table:

| Surface Maintenance Limits | | | | | |
|---|---|---|---|---|---|
| Track Surface | Class of Track | | | | |
| | 1 | 2 | 3 | 4 | 5 |
| The deviation from uniform profile on either rail at the mid-ordinate of a 62' chord may not be more than (inches): | 1 | 7/8 | 3/4 | 5/8 | 1/2 |
| The deviation from zero crosslevel at any point on a tangent may not be more than (inches): | 1 | 3/4 | 5/8 | 1/2 | 3/8 |
| The difference in cross- level between any two points less than 62' apart may not be more than (inches): | 1 | 3/4 | 3/4 | 5/8 | 1/2 |

(b) The difference in crosslevel between any two points less than 10' apart is designated as short warp and may not be more than (inches):

| Track Surface | Class of Track |
|---|---|
| | 1-5 |
| Short warp | 1 |

### §109.0(MRM) Support Timber

(a) It is recognized that the effective operation of miter rails and rail expansion joints depends on a sound timber and steel tie support system.

(b) Every effort must be made to ensure that there are no defective bridge timber, steel ties or wood ties under any miter rail assembly or rail expansion joint.

### §115.0(MRM) Rail End Mismatch

Rails shall be maintained so that the mismatch of rails at joints may not be more than that prescribed in the following table:

| Rail End Maintenance Limits | | |
|---|---|---|
| Class of Track | Any mismatch of rails at joints may not be more than the following: | |
| | On the head of the rail ends (inch) | On the gage side of the rail ends (inch) |
| 1-3 | 1/8 | 1/8 |
| 4-5 | 3/32 | 3/32 |

### §119.0(MRM) Continuous Welded Rail (CWR)

See Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

**§120.0(MRM) Field Welding**

(a) Thermite and flash butt are acceptable methods for in track field welding and shall be performed in accordance with EP 2003 & EP 2027.

(b) Field welding on open deck bridges to include miter rails is permitted provided the following conditions are met:

(1) A qualified individual using a 17-pound dry chemical ABC extinguisher is available to protect against fires.

(2) A qualified individual must be present for a period of at least two hours after the last field weld is finished and ground.

(3) An extra 17-pound ABC extinguisher must also be readily accessible as a backup.

(4) While extinguishing any fires, the qualified individual must stand upwind and aim the chemical at the base of the fire.

(5) A qualified B&B representative must be present during the entire welding operation from the beginning of the welding process to at least two hours after the last field weld is finished and ground.

(6) Flash butt welding, shearing and grinding shall only be performed when there is no highway or river traffic directly under the area of the welding.

(7) Bridge timber spacing may be more restrictive than that of ballasted track. Welding shall not be performed if the tie crib is less than 5-1/2" in width.

(8) Welds on open deck bridges must be made as close to the center of the crib as possible. The minimum distance between the center of weld and the edge of tie shall be 2-3/4".

(9) After welding, the entire structure should be inspected for possible "hot spots" or fire.

(c) In no case will a field or plant weld be made within 6" of a bolt hole.

**§121.0(MRM) Bolts and Braces**

(a) During the useful life of a miter rail or expansion joint assembly, it may be required to replace bolts as part of a programmed maintenance activity.

(b) Bolts, braces and blocks found in miter rails and sliding rails (expansion joints) must always be in place and kept tight.

(c) Bolt replacement shall be performed on an as-needed basis as traffic and local conditions warrant.

(d) Preferred torque values for bolts are given in the following table:

| Bolt Maintenance Torque Requirements (Preferred) | |
|---|---|
| **Diameter of Standard Bolt (Inches)** | **Preferred Dry Thread Torque (ft-lbs.)** |
| 7/8 | 470 |
| 1 | 710 |
| 1-1/8 | 960 |
| 1-1/4 | 1,350 |
| 1-3/8 | 1,750 |

### §123.0(MRM) Pads and Shims; Steel Ties

### §123.1(MRM) Shims

(a) Holes in shims placed between the elastomer pad and steel tie are not to exceed the diameter of the steel sleeves at each bolt hold-down location (four locations per pad). Shim holes should be 15/16" in diameter. Oversized holes will not allow the sleeve to bear on the shim during bolt tightening, resulting in damaged elastomer pads.

(b) Shims that are corroded and/or loose or improperly made should be renewed with a single shim made of steel or other approved material.

(c) Stacking of multiple thin shims under elastomer pads is undesirable. If additional shims are required to correct surface irregularities, multiple shims should be removed and replaced with a single shim.

(d) Tapered shims, at a few locations may be necessary since the top of some steel ties may not be level. This can be determined by placing a 6' straightedge over several steel ties. If one edge of the tie is lower than 1/8" as measured with a taper gage, then a tapered shim is required.

### §123.2(MRM) Elastomer Pads

(a) Pads should be renewed if more than 1/2 of the elastomer has been torn loose or separated from the top perimeter of the washer plate.

(b) Pads should be renewed if the elastomer is bulging so that the overall thickness of the pad in the rail seat area has been reduced by more than 3/16" from the original 1-3/4" thickness.

### §125.0(MRM) Rail Anchoring

See Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

### §127.0(MRM) Track Fastening Systems

See Part I, §127.0(M) for fastener requirements on or about bridges.

### §143.0(MRM) Guard Rails and Guard Faces; Gage

(a) Maintenance limits: By design, not all miter rails have guard rails. Whenever possible, and if the assembly has a guard rail, the following limits shall apply:

| | |
|---|---|
| Track gage | 56-1/2" |
| Guard check gage | 54-5/8" |
| Guard face gage (back-to-back) | 52-3/4" |

(b) The guard face gage distance (back-to-back) between the wheel flange face of the guard rail and the wheel flange face of the opposite guard rail must be maintained at 53" or less regardless of the class of track.

### §145.0(MRM) Inner Bridge Guard Rails

See Part I, §145.0(M) for the general requirements for and the use of guard rails on bridges.

### §150.0(MRM) Production Rail Grinding

(a) When production rail grinding is scheduled for areas on a moveable bridge, the approaches to the bridge should be production ground to restore original rail contour and align the wheels as they approach the miter rail or expansion rail. Production grinding should extend 150' on the approaches.

(b) Rail grinding on open deck bridges is permitted provided the following conditions are met:

   (1) A qualified individual using a 17-pound dry chemical ABC extinguisher is available to protect against fires.

   (2) A qualified individual must be present for a period of at least two hours after the last field weld is finished and ground.

   (3) An extra 17-pound ABC extinguisher must also be readily accessible as a backup.

   (4) While extinguishing any fires, the qualified individual must stand upwind and aim the chemical at the base of the fire.

   (5) A qualified B&B representative must be present from beginning of grinding process to at least two hours after completion.

# SUBPART A

# LIMITS AND SPECIFICATIONS FOR MITER RAIL AND EXPANSION JOINT CONSTRUCTION

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**LIMITS AND SPECIFICATIONS FOR MITER RAIL AND EXPANSION JOINT CONSTRUCTION SUBPART A**
**Track Classes 1-5**

## Table of Contents

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## Subpart A(MRC) — Construction Limits

### §50.0(MRC) Scope

(a) Construction is the complete replacement of track structure from subgrade to top of rail. It should always be the goal to complete construction projects to a zero tolerance. This is not always practical given such variables as rail rolling tolerances and manufacturing limitations. Therefore, construction tolerances have been developed.

(b) This subpart prescribes construction requirements for the gage, alignment, and surface of miter rails and expansion joints.

### §53.0(MRC) Gage

### §53.1(MRC) Standard for Gage

(a) The standard gage for track, measured between the running rails at right angles to the alignment of the track 5/8" below the top of rail, is 56-1/2".

(b) Gage shall be changed by adjustment of the rail opposite the line rail.

### §53.2(MRC) Setting of Gage

(a) Gage shall be measured with a standard track gauge or other authorized devices. These devices must be checked daily for accuracy prior to use.

(b) For construction, provided that the gage is uniform, the following deviations from standard gage are permitted:

| Gage Construction Tolerances | | |
|---|---|---|
| Class of Track | Minimum (inches) | Maximum (inches) |
| 1-3 | 56-13/32 | 56-5/8 |
| 4-5 | 56-13/32 | 56-9/16 |

### §55.0(MRC) Alignment

(a) General track alignment, as viewed from above, consists of a series of straight lengths of track, referred to as tangents, connected by simple, compound and reverse curves.

(b) Alignment (line) is the condition of track with regard to uniformity of direction over short distances on tangents and in curves.

### §55.1(MRC) Alignment Tolerances for Construction

(a) The following standards shall be used for the construction of new track and restoration of existing track that includes miter rails or expansion joints.

| Class of Track | Alignment Construction Standard for Tangent Track |
|---|---|
| | The deviation of the mid-ordinate from a 62' chord may not be more than (inches): |
| 1 | 3/8 |
| 2-5 | 1/8 |

## §63.0(MRC) Track Surface

### §63.1(MRC) General

Track surface is the relationship of opposite rails to each other in profile and crosslevel. Track profile is the running surface along the top of the grade rail. Crosslevel is the difference in elevation of the tops of heads of opposite rails, measured at right angles to the track alignment. The ideal surface is a uniform profile consisting of constant grades connected by vertical curves, with zero crosslevel on tangents and predetermined crosslevels on curves.

### §63.2(MRC) Tolerances

(a) The construction limits for track surface through miter rails and expansion joints are contained below:

| Construction Track Surface Limits | Track Classes | | |
|---|---|---|---|
| | 1-2 | 3 | 4-5 |
| The deviation from uniform profile on either rail at the mid-ordinate of a 62' chord may not be more than (inches): | 1/2 | 1/4 | 1/8 |
| The deviation from zero crosslevel at any point on a tangent may not be more than (inches): | 1/2 | 1/4 | 1/8 |
| The difference in crosslevel between any two points less than 62' apart may not be more than (inches): | 1/2 | 1/4 | 1/8 |

## §109.0(MRC) Support Timber

When installing new miter rail or expansion joint assemblies all defective bridge timber, steel tie components (pads and bolts) and wood ties shall be replaced with new materials.

## §115.0(MRC) Rail End Mismatch

Any mismatch of rails at joints may not be more than that prescribed in the following table:

| Rail End Mismatch Construction Limits | | |
|---|---|---|
| Class of Track | On the head of the rail ends (inch) | On the gage side of the rail ends (inch) |
| 1-3 | 3/32 | 3/32 |
| 4-5 | 1/16 | 1/16 |

## §119.0(MRC) Continuous Welded Rail

See Amtrak Procedures manual for the installation, adjustment, maintenance, and inspection of CWR.

### §121.0(MRC) Bolt Torque

Preferred torque values for bolts are given in the following table:

| Construction Bolt Torque Requirements (Preferred) | |
|---|---|
| **Bolt Diameter (inches)** | **Preferred Dry Thread Torque (ft-lbs.)** |
| 7/8 | 470 |
| 1 | 710 |
| 1-1/8 | 960 |
| 1-1/4 | 1,350 |
| 1-3/8 | 1,750 |

### §125.0(MRC) Rail Anchoring (Bridges)

See Part I, §125.0(C).

### §127.0(MRC) Track Fastening Systems (Bridges)

See Part I, §127.0(C).

### §143.0(MRC) Guard Rails and Guard Faces; Gage

(a) By design, not all miter rails have guard rails. If the assembly has a guard rail, the following limits shall apply:

| | |
|---|---|
| Track gage | 56-1/2" |
| Guard check gage | 54-5/8" |
| Guard face gage (back-to-back) | 52-3/4" |

(b) The guard face gage distance (back-to-back) between the wheel flange face of the guard rail and the wheel flange face of the opposite guard rail must be maintained at 53" or less regardless of the class of track.

### §145.0(MRC) Inner Bridge Guard Rails

See Part I, §145.0(C) for the construction requirement for the use of guard rails on bridges.

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## MASTER INDEX

This Master Index is sorted by subject and cross references the appropriate paragraph number and part and page number for Parts I, II and III.

The following table shows the relationship of acronyms and part numbers used in Parts I, II and II and the Master Index.

| | Part # | Safety | Maintenance | Construction |
|---|---|---|---|---|
| Conventional Track | I | None Example: §213.53 | (M) §53.0(M) | (C) §53.0(C) |
| Turnouts and Other Trackwork | II | (TO) Example: §213.53(TO) | (TOM) §53.0(TOM) | (TOC) §53.0(TOC) |
| Miter Rail and Expansion Joint | III | (MR) Example: §213.53(MR) | (MRM) §53.0(MRM) | (MRC) §53.0(MRC) |

## Master Index  Parts I, II and III

## MASTER INDEX FOR APPENDICES A, B, C, AND E

This master index is sorted alphabetically by subject title.

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# Appendix A Glossary of Terms

## A

### Adjusting / De-stressing
The procedure by which a rail's temperature is re-adjusted to the desired value. It typically consists of cutting the rail and removing rail anchoring devices, which provides for the necessary expansion and contraction, and then re-assembling the track.

### Alignment - General
The physical appearance of the railroad as viewed from above, which consists of a series of straight lengths of track, referred to as tangents, connected by simple, compound or reverse curves.

### Alignment - Line
The condition of track in regard to uniformity of direction over short distances on tangents and in curves.

### Aggregate
The sand, gravel, broken stone or combinations thereof with which the cementing material is mixed to form a mortar or concrete. The fine material used to produce mortar for stone and brick masonry and for the mortar component of concrete is commonly termed "fine aggregate," while the coarse material used in concrete only is termed "course aggregate."

### Anticreeper
See Rail Anchor.

## B

### Ballast
Selected material placed on the roadbed to support and hold track in line and surface. Ballast preferably consists of sized hard particles easily handled in tamping that distribute the load, drain well and resist plant growth.

### Ballast Cleaning
The process of separating dirt from the ballast by shaking and depositing stone back onto the track.

### Ballast Section
The cross section of a track around and under the crossties and between and above the toes of the ballast slopes. This section may include sub-ballast.

### Ballast Shoulder
The portion of ballast between the end of the tie and the bottom of the ballast slope. It distributes the traffic load over a greater width of roadway and helps hold the track in alignment by providing lateral resistance.

### Bar - Splice
Bars that are used to physically connect two rail ends and ensure proper rail head and gage face alignment. Also called a joint bar.

### Bascule Bridge
A movable bridge span that is hinged at one end. When being raised or lowered, end of the span opposite the hinge follows the arc of a circle.

### Batter - Rail
Deformation of the surface of the rail head usually close to the end of the rail.

### Brace - Rail
A device used in Special Track Work in combination with switch, tie or gage plates, for holding rail in place and to dissipate lateral forces preventing rail turnover.

### Braking Force
The longitudinal force induced into the rail as a result of brake application of a train.

### Bridge - Ballast Deck
A bridge with a solid floor provided with drains and covered with ballast to provide normal and uniform support for track and conforming generally to standard construction used in the same tracks as constructed on roadbed.

### Bridge Timber
A sawed tie usually pre-framed and of the size and length required for track on an open deck bridge. Usually hardwood.

### Buckling Incident
The formation of a lateral misalignment sufficient in magnitude to constitute a deviation from the Class 1 requirements specified in §213.55 / 213.055 Part I. These normally occur when rail temperatures are relatively high and are caused by high longitudinal compressive forces.

## C
### Cant
Tilt or inclination, as the inward inclination of a rail, accomplished by using canted tie plates. The undesirable outward tilt of tie plates on sharp curves.

### Clip - "e"
An elastic fastener that is applied parallel to the base of the rail and replaces and eliminates the need for a cut spike and anchor. This clip can be used on wood or concrete ties.
### Clip - Fast
An elastic fastener that is applied perpendicular to the base of the rail. This clip is generally used on concrete ties.

### Clip - Switch
The device by which the switch rod is jointed to the switch rail. It is usually connected to the switch rail by bolts or rivets. It sometimes has staggered bolt holes in the horizontal leg for making detailed adjustments in positions of the switch rails.

### Closure Rail
The lead rails connecting the heels of a switch with the toe ends of a frog.

### Coefficient of Thermal Expansion - Rail
A multiplier based on the physical properties of rail steel used to calculate the change in rail length with change in temperature.
### Compression
An axial force or stress caused by equal and opposite forces pushing at the ends of a member.

### Compromise Joint Bars
Special joint bars to connect rails of different section in such a way that the gage sides and the top of the head and running surfaces are held in line. Also called offset bars.

### Continuous Welded Rail (CWR)
Refer to CWR Procedures.

### Cropping
The process of reducing Rail length by removing a portion at its end(s), usually to remove Rail Defects or Bolt holes.

### Cross Level
The distance one rail is above or below another. This should not be confused with superelevation on curves.

### Crossing - Bolted Rail
A crossing in which all the running surfaces are of rolled rail with parts held together with bolts.

### Crossing - Bolted Three Rail
A crossing in which the end frogs and center frogs and the connections between them consists of rolled running rails, guard rails and easer rails.

### Crossing - Bolted Two Rail
A crossing in which the end frogs and center frogs and the connections between them consists of rolled running rails and guard rails.

### Crossing - Grade (Highway)
A crossing or intersection of a railroad and a highway at the same level or grade.

### Crossing - Grade (Track)
A structure used where one track crosses another at grade, which consists of four connected frogs. Crossing angles can be defined as:

- Low angle: Up to and including 30o Medium angle: 31° to 60°
- High angle: 61° to 90°

Also called Diamond

### Crossing - Manganese Steel Insert
A crossing in which a manganese steel casting is inserted at each end of the four intersections, being fitted in to rolled rails and forming the points and wings of the crossing frogs.

### Crossing - Moveable Point
A crossing of small angle in which each of the two center frogs consists essentially of a knuckle rail and two opposed moveable center points with the necessary fixtures.

### Crossing - Solid Manganese Steel
A crossing in which the frogs are of the solid manganese steel type.

### Crossover
Two turnouts with the track connecting their frogs, arranged to form a passage between two nearby and generally parallel tracks.

### Curvature - Degree of
A measure of the sharpness of a simple curve in which a 1° curve is taken as the central angle subtended by a chord or arc of 100' and for which the radius is taken as 5,730'. Sharper curves are in direct proportion, i.e., a 10° curve is taken as one having a radius of 573'. Railroads use the chord definition, highways the arc definition.

### Curve - Compound
A curve composed of two or more simple curves that join on common tangent points or common easement curves and that lead in the same general direction, i.e., to left or right, but each with different radii.

### Curve - Reverse
A curve composed of two simple curves that join a common tangent point or by a short tangent track or a reverse curve, and bear in opposite directions, i.e., left and right or vice versa.

### Curve - Simple (Horizontal)
A curve in the form of a circular arc that is bounded by two tangents.

### Curve - Vertical
A curve in the profile of a track to connect intersecting grade lines and to permit safe and smooth operation of trains over summits and across sags.

## D
### Derail
A track safety device to guide rolling stock off the rails at a selected spot and divert the rolling stock away from the track that is being protected. Derails provide protection against collisions or side swipes. Derails are generally of three kinds: the “split switch,” the “sliding block," and the "hinged block” type.

### Derailment
Anytime the wheels of a car or engine are off the head of the rail.

### Deviation
Difference between a design or published standard and actual measurement at any one location.

### Dynamic Train Loading
Forces that are imparted to the track structure during the passing of a train due to wheel action and vehicle response.

## E
### Easer Rail
A rail placed with its head along the outside and close-up to the head of the running rail and sloped at the end to provide a bearing for the overhanging portion of hollowed-out treads of worn wheels.

### Engine Burn
Destruction of rail head metal caused by spinning locomotive wheels. Engine burn fracture is a rail break caused by an engine burn.

### Established Neutral Temperature
The temperature at which rail is secured in a stress-free condition.

### Expansion Joint
A device that allows thermal stress in rail to be relieved by allowing the rail on one side of the joint to freely expand and contract. Often installed on the approaches to movable bridges so that thermal stress and movement in continuous welded rail adjacent to the bridge cannot be transferred into the miter rail assembly, where it could jam and prevent needed movement.

### Expansion Shim (Rail)
Spacer inserted between ends of abutting rails while track is being laid to provide allowance for expansion of steel when temperature changes.

## F

### Facing Point
A switch where the points face the normal direction of traffic. A facing point move is one where the rail vehicle moves over the switch points and then the frog.

### Federal Railroad Administration (FRA)
A government agency in the U. S. Department of Transportation.

### Fishing Space
Space between the head and base of a rail occupied by a splice bar (angle bar, joint bar).

### Fit Material
Useable secondhand rail, ties or other track material (OTM).

### Flangeway
Space between running rail, guard rail, frog casting, frog wing rail or timber in road crossing to provide clearance for passage of wheel flanges.

### Flow of Metal (Rail)
Rolling out of steel on the crown of a rail toward sides of the head. More common on the low side of a curve located where less than established speed is used frequently.

### Fracture - Detail
A progressive transverse fracture originating in the head of a rail.

### Frog
A device used where two running rails intersect, providing flangeways to permit wheels and wheel flanges on either rail to cross the other.

### Frog - Actual Point
The actual point of frog, also called the 1/2 inch point of frog, is the point at which the spread between gage lines is 1/2", which is the standard width of all manufactured frog points except solid manganese steel frogs. In the latter, the metal point is 5/8" wide, but the 1/2" is marked on the casting. All measurements are made from the 1/2" point of frog.

### Frog - Moveable Point (MPF)
An assembly that consists of a frog housing and "vee" rails that are welded together or forged as one piece to form a moveable point. This point is moved to the normal position or reversed by a switch machine(s) to direct wheels through the frog area. This frog type is used in a No. 15 or higher turnout and is the preferred type of frog for Track Classes 6- 9 operating speeds where safety of operation and ride quality are of primary concern. The MPF design provides for a continuous bearing surface for the wheel tread as it traverses through the frog.

**Moveable Point Frog**

### Frog - Point
That part of the frog lying between the gage lines extending from their intersection towards the heel end of the frog.

### Frog - Rail Bound Manganese
A frog assembly that consists of wing rails and a manganese casting with a rigid frog point and flangeways to permit the safe passage of trains.

### Frog - Rigid Bolted
A frog built entirely of rolled rails, with fillers between rails, and rigidly held together with bolts.

### Frog - Self-Guarded
A frog with a guard member for guiding the flange of a wheel past the point of frog by engaging the tread rim of the wheel in a horizontal plane above the top of the running surface of the frog. This makes a conventional guard rail unnecessary.

### Frog - Solid Center Slip
Appliance found in the center of slips. Two center frogs replace the need for center switch point assemblies. Each frog has a built in guard to protect moves through adjacent frog.

### Frog - Spring
An appliance that contains, among other things, a fixed frog point, a moveable spring wing rail, a rigid wing rail, frog hold-down assemblies, and spring box. The frog makes use of a 27' guard rail (on the straight side). The spring frog design provides a continuous bearing surface for the wheel tread as it traverses through the frog point area.

**Spring Frog**

### Frog - Theoretical Point
The theoretical point of the intersection of the gage lines. The theoretical frog point is at a distance, in inches, ahead of the 1/2 inch point which is equal to one-half the frog number.

### Frog - Throat of
Point at which the converging wings of a frog are closest together.

### Frog - Welded Heel Manganese (WHM)
A frog where the heel of the manganese insert is flash butt welded to the heel rails. A stainless steel section to facilitate welding is used between the manganese insert and rail steel heel rails.

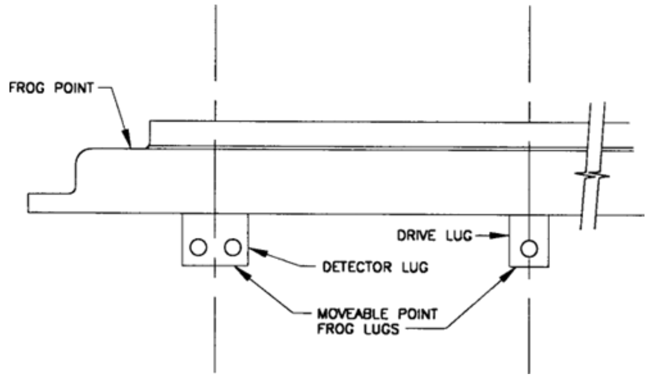
### Frogs - Center
The two frogs at the opposite ends of the short diagonal of a crossing or slip.

### Frogs - End
The two frogs at the opposite ends of the long diagonal of a crossing or slip.

### Frog Angle
Angle formed by intersecting gage lines of the rails in a frog.

### Frog Number
The frog angle expressed as the number of units of centerline length in which the spread is one unit.

### Frog Point Lug
The forging or welded plate attached to the "vee" rail to which the switch machine rod and basket and circuit controller rod assemblies are attached. The integrity of this lug is critical for the safe operation of the moveable point frog.




**Moveable Point Frog Drive and Detector Lug Locations**

## G

### Gage Line
A line 5/8" below the running surface of a rail on the side of the head nearest the track center; the line from which measurements of gage are made.

### Gage of Track
Distance between gage lines of rails laid in track.

### Gage Rod
A device for holding track to correct gage, generally consisting of 1-1/4" rod with a forged jaw on one end and a malleable jaw on the other end, adjustable through a locknut. Sometimes consists of a rod made in two parts with a solid jaw on each end, united by a turnbuckle. Also called a tie rod.

### Gaging of Track
Bringing the opposite rails of a track into their correct relative distance apart.

### Grade
Rate of rise or fall of the grade line, expressed as a percentage of length; feet of rise or fall per 100' of length. Also, gradient. A steady rise or fall of 1' per 100' is a 1% grade.

### Grade Line
The line representing top-of-rail elevations and the profile of track.

### Grade Rail
The rail first surfaced to track elevation; the line rail on tangents, the inner or low rail on curves.

### Guard Rail - Frog
A rail section assembly used in a turnout with a rail bound manganese (RBM) frog, spring rail frog, or in track crossings. The guard rail is designed to guide the wheel set through the proper flangeway of the frog. The guard rail prevents the wheel flange from wearing, striking or picking the frog point.

### Guard Rail - Inner Bridge
An additional rail or rails laid parallel to and between the running rails of bridges, bridge approaches, and at other critical locations to prevent derailed equipment from striking a bridge or other structure and to keep the derailed wheels on the ties and within the running rails of the track.

## H

### Head Block - Switch
A pair of ties (or, in old types of turnouts, a single tie) used to support the switch-point operating mechanism and the switch stand.

### Head Rod
The switch rod nearest the point of a switch, usually placed between the two head block ties.

### Heater - Switch
See Switch Heater.

### Heel Block - Fixed
A rigid heel block assembly at the switch heel to maintain the proper horizontal heel spread between the switch rail and stock rail. The heel block limits the amount of longitudinal movement between the switch point and stock rail. The heel block is bolted to the switch rail and stock rail.

### Heel Block - Floating
An assembly at the switch heel to maintain the proper horizontal heel spread between the switch rail and stock rail. The assembly is bolted to the switch rail only. Therefore, the switch heel "floats."

### Heel Block - Switch
A block that fills the space and maintains the relationship between a switch point and stock rail.

### Heel Length
Distance between the heel end and half-inch point of a frog, measured along gage lines.

### Heel of Frog
The end of a frog farthest from the switch.

### Heel of Switch
The end of the switch where the switch point connects to the closure rails (see Heel Block - Fixed and Floating). The heel of the switch can be either fixed to the stock rail or allowed to float freely.

### Heel Spread - Frog
Distance between gage lines at the heel end of a frog.

### Heel Spread - Switch
The distance between the gage lines of the stock rail and switch rail at the heel of the switch.

### Highway-Crossing Warning Devices (Active)
An arrangement of one or more highway-crossing signals, with or without gates, to protect highway traffic.

## I

### Impedance Bond
An electrical apparatus at code change points in electric traction areas to separate signal and traction current.

### Interlockings
An arrangement of signals, switch locks, and signal appliances so interconnected that their movements succeed each other in a predetermined order. It may be operated manually or automatically.

## J

### Joint
The junction of two rails or of like materials in bridge members.

### Joint Bar
A steel angle bar or other shape used to fasten together the ends of rails in a track. They are used in pairs and are designed to fit the space between head and flange (fishing space) closely. They are held in place by track bolts. Also called angle bar, rail joint bar, and splice bar.

### Joint Bar - Compromise
A special rail joint, sometimes called a step joint, for joining rails of different sections. The joint is made so that it brings gage faces and rail heads into line so that a continuous smooth surface is present for the treads and flanges of passing wheels. The hand of a compromise joint is designated by standing in the gage of track at the small rail section looking or facing towards the heavier rail section to be joined or compromised. In this location in track, the right hand compromise joint is on the right and left hand is on the left. A compromise joint is described by indicating the heavier rail section and then the lighter rail section, i.e., 132/115.

### Joint - Frozen
A joint so tight that the rails cannot move within the joint bar as temperature varies.

### Joint - Insulated
A rail joint designed to arrest the flow of electric current from rail to rail by means of insulation so placed as to separate the rail ends and other metal parts connecting them.

### Joints - Supported and Suspended
A supported rail joint has a tie directly under the rail joint. A suspended joint is one in which ends of the rail joint are carried by two consecutive ties.

### Joint Tie
A cross tie used under a rail joint.

## K

### Knuckle Rail
A bent rail, or equivalent structure, forming the obtuse point against which the moveable center points, of a moveable point crossing or slip switch, rests when set for traffic.

## L

### Latch - Switch Stand
A device for catching and holding the lever of a switch stand in position, also called a switch keeper. Two latches are used at each switch stand.

### Lateral Acceleration
The horizontal acceleration experienced by a rail vehicle that is perpendicular to the direction of travel. Lateral acceleration is a measure of ride quality and measured in units of ft./sec2 (g).

### Lateral Resistance
The ability of the track structure to remain in position under the influence of in-service forces that are generated in a plane perpendicular to the line of the rail. Lateral resistance is a product of interaction of the ballast with the sides, bottom, and end face of the tie.

### Lead - Actual
The length between the actual point of switch and the 1/2" point of frog, measured on the line of the straight track.

### Lead - Curve
The degree of curvature in a turnout between the heel of the switch and the toe of the frog, measured on the centerline of the turnout track.

### Level
The condition of a track in which the elevation of the rails is transversely equal. Also a tool used to determine that condition in surfacing track.

### Lift Bridge
A movable bridge on which the entire moving span is lifted vertically from both ends.

### Lift Rail
The portion of a miter rail assembly that is attached to the mobile span of a movable bridge. Sometimes called the bridge rail or movable rail.

### Line
The condition of track in regard to uniformity in direction over short distances on tangents or uniformity in variation in direction over short distances on curves.

### Line Rail
The rail on which alignment is based; the east rail of tangent track running north and south, the north rail of tangent track running east and west, the outer rail on curves, or the outside rails in multiple track territory.

### Lining Track
Shifting the track laterally to conform to an established alignment. Maintenance lining is ordinarily done during repairs; general lining is done to make the track conform to predetermined alignment.

### Longitudinal Resistance
The ability of the track structure to remain in position under the influence of train and temperature forces that run parallel to the rail. Longitudinal resistance is a product of the interaction of the ballast, the tie, rail anchors, rail clips and other elastic fasteners.

### L/V Ratio
The relationship of lateral force on the rail to the vertical force on the rail, which is produced by the wheel of railroad rolling stock, work equipment and other equipment moving along the track.

## M
### Maximum Authorized Speed (Authorized Speed)
That speed for a portion of track as specified in the current Employee's Timetable.

### Mechanical Stabilization
A type of procedure used to restore track resistance to disturbed track following certain maintenance operations. This procedure may incorporate dynamic track stabilizers a unit of work equipment that are used as a substitute for the stabilization action provided by the passage of tonnage trains.

### Middle Ordinate
The distance measured from gage line or rail on a curve to the middle of a string drawn taut and held to contact with the gage line of rail at its end. The middle ordinate forms a convenient means of measuring detailed curvature and is used in the adjustment of curves and the investigation of accidents. It is also a factor in bending rails to a desired curvature.

### Miter Rail
A rail assembly on a movable bridge that spans the gap between the movable span and the adjacent stationary portion of the bridge. The miter rail typically consists of two pieces, one of which is stationary or fixed and attached to the non-moving portion of the bridge and the second of which is attached to and moves with the moving portion of the bridge.
The term miter is used because typically the abutting ends of the two portions of the miter rail assembly, rather than being cut square as in a conventional rail joint, are cut at an acute angle or "mitered" relative to each other. This can provide the wheels with continuous support over the miter gap.
Because one rail must be able to move relative to the other when the bridge is being opened, the abutting ends of the miter rail assembly are not bolted to each other as in a conventional rail joint, but rather sit in chairs that align one end of the miter rail to the other.

### Moveable Bridge
Any bridge span over a navigable waterway that can be moved in order to accommodate vessels taller than the normal under clearance of the bridge.

### Moveable Center Point
One of the moveable tapered rails of a moveable point crossing or slip switch.

## N
### Neutral Temperature
The temperature at which rail is secured in a stress-free condition having neither compressive nor tensile stress.

### Neutral Temperature Management
Maintaining the condition of the track structure so that the neutral temperature of the rail remains near its installed neutral temperature.

### Number - Turnout
The number corresponding to the number of frog used in a turnout.

## O
### Out-of-Face Surfacing or Lining
Surfacing and/or lining a continuous piece of track in excess of 200'.

### Out-of-Face Tie Renewal
Tie replacement at the rate of more than four (4) ties per 39' of rail. Not more than three (3) consecutive ties nor more than eight (8) ties per 39' of rail can be replaced in any one pass.

### Out-of-Face Undercutting
Undercutting of more than one consecutive tie or more than four ties in 39' of track.

### Overbalance
The amount that superelevation exceeds equilibrium superelevation, and is produced by the operation of a train around a curve at less than equilibrium speed, or stopping on the curve.

## P
### Point of Switch - Actual
The working point of switch which is half the frog number in inches behind the theoretical point of switch.

### Point of Switch - Theoretical
The point where the gage line of the switch rail, if produced, would intersect the gage line of the stock rail. Also called vertex.

### Post - Bumping
A device at the end of a stub track to prevent rolling stock from going off the ends of the rails.

### Profile
A longitudinal section through a track that shows elevation of the running rails. The profile is usually obtained from levels taken on top of the rail.

## R
### Rail
A rolled steel shape designed to be laid end-to-end in two parallel lines on ties to form a track for railroad rolling stock, traveling cranes, and the like.

### Rail - High
The outer or elevated rail of a curved track, which is maintained as the line rail.

### Rail - Low
The inner rail of a curve, which is maintained as the grade rail.

### Rail - Running (Surface)
The position on the rail head that the wheel tread contacts.

### Rail - Scrap
Rails of standard section not fit for use as relayer rail.

### Rail – Tight / Kinky
CWR which exhibits minute alignment irregularities which indicate that the rail is in a considerable amount of compression.

### Rail Anchor
A device attached to a rail, and bearing against a crosstie, to keep the rail from moving longitudinally as a result of temperature changes or forces from rail traffic. Also called anticreeper.

### Rail Bender
A tool or shop machine for bending rails to fit curves in tracks, turnout, or turntable circles; to introduce bend in stock rails; and for a variety of allied operations. Two common types are the Samson and the Jim Crow, the latter sometimes modified by addition of a roller for continuous bending of rails.

### Rail Bond
A device used to transfer an electric circuit across rail ends at a rail joint.

### Rail Brace
A metal casting made to fit against the side of a rail and to be fastened to the tie plate on the outside of a track to prevent the rail from rotating due to lateral wheel forces.

### Rail Brand
An identification mark, including manufacturer's name or initials, month and year the rail was rolled, weight per lineal yard, initials of section, number of the heat, portion of the ingot, and process of manufacture.

### Rail Creeping
Intermittent longitudinal sliding movement of rails in track under traffic or because of temperature changes. The effect of rail creeping is resisted by anticreepers or rail anchors.

### Rail Fastening System
The hold-down appliances that provide the required combination of horizontal, lateral, and vertical restraint to permit the safe operation of rail vehicles. Examples of systems found on Amtrak include the cut spike, Pandrol "e" clip, fast clip and coach screw.

### Rail joint - Block

### Rail Joint - Insulated
A rail joint designed to stop the flow of electric current from rail to rail, as at the end of a track circuit, by means of nonconductors so placed as to separate rail ends and other metal parts. Sometimes called an insulated joint.

### Rail Joint - Pumping
A rail joint usually poorly supported so that mud is created by passage of wheels and pumped up through ballast.

### Rail Joint Base Plate
A special tie plate used under some types of rail joints.

### Rail Joint Expander
A rail puller/expander operated by hand or by machine that increases or decreases the gap between adjoining rail ends.

### Rail Section
The pattern or dimensional details of rail, such as width of base, height of rail, thickness of web, width and thickness of head, angle of head, and angle of base. Each particular pattern is identified by a brand name or symbol, such as ASCE, AREA, ARA, PRR, etc. in addition to its weight per yard.

### Rail Temperature
The temperature of the rail, measured with a rail thermometer.

### Rail Weight
The weight of a three (3)-foot-long section of rail expressed in pounds.

### Reverse Elevation
The condition where the outside rail of a curve is lower than the inside rail.

### Rider Rail
A rail placed on the outside of the running rail that is designed to intercept the outer edge of the wheel, lift it up, and carry it over the gap in a miter rail.

### Right of Way
Land or water rights used for the railroad roadbed and its structures.

### Roadbed
The finished surface of roadway upon which track and ballast rest.

### Roadbed Shoulder
The portion of subgrade lying between the ballast-covered portion and the ditch in cuts and the top of slope on embankments.

### Roadway
The part of a railway prepared to received track. During construction, the roadway is often referred to as the grade.

### Rocker Rail
In a three-piece miter rail assembly for swing bridges, the segment in the center that spans the gap between the moving and stationary spans and "rocks" vertically out of the way during a bridge opening.

### Rod - Operating
A rod attached to a switch, derail, or other device, for moving it from one position to another.

### Running Rail
The rail or surface on which the wheel bears, as distinguished from a wing rail or guard rail.

### Runoff - Curve
The change in superelevation from the full body of a curve to tangent or between compound curves.

### Runoff - Surface
The grade through which the raised portion of a track is connected with the old grade. It generally includes the two rails and is made at a long easy slope for comfort and safety.

## S
### Scrap
Rail, ties or other track materials (OTM) that are not suitable for reuse.

### Screw - Coach
A cylindrical threaded steel spike with a special head, designed to be turned with a special wrench into holes bored in ties to secure rails or to act as a tie plate holder in tie plates with holes intended for its use.

### Shim - Track
A bearing piece, usually wood or metal of various thickness, at least equal to the width and length of the tie plate, for temporary use between the tie plate and ties to raise (surface) the rail to a desired relative elevation. Usually used to spot surface a track when the roadbed is frozen and the ties cannot be surfaced tamped or for temporary use to bring the tops of adjoining rails of different height to a desired plane or elevation.

### Side Planing
Cuts made on sides of the head of the switch rail to form a taper from the full width of head to the point. Also used in a stock rail to accommodate undercut switch points.
Slip Switch - Double
A combination of a crossing with two right-hand and two left-hand switches and curves between them within the limits of the crossing and connecting the two intersecting tracks on both sides of the crossing and without the use of separate turnout frogs.

### Slip Switch - Single
A combination of a crossing with one right-hand and one left-hand switch and curve between them within the limits of the crossing and connecting the two intersecting tracks without the use of separate turnout frogs.

### Smoothing
Smoothing and lining where not more than five consecutive ties are lifted from their tie beds and not more than five ties are lifted in any 39' length of track.

### Specialized MW Equipment:
MDZ - A track geometry unit composed of three pieces coupled together: the 09-32 or 09-16 cat tamper, high-capacity ballast regulator, and dynamic track stabilizer. All three pieces must be coupled together when traveling to ensure a positive shunt. If not coupled together, the Dispatcher must be notified and the equipment operated under track car rules.
08-Unimat Switch Tamper 09-4S Combo Tamper
Ballast Management System (BMS) - A high-capacity ballast regulating and distributing machine. The BMS is designed to shunt with or without its conveyor or transfer car.

### Special Track Work
Any Track work constating of more than two Rails and Ties or Timber.  Some Examples of Special Track Work are Turnouts, Switches, Frogs, Crossings, etc.

### Spot Surfacing
Refer to CWR Procedures.

### Spot Tie Renewal
Refer to CWR Procedures.

### Stationary Rail
Sometimes called the approach rail or fixed rail, it is attached to the fixed portion of a movable bridge.

### Stock Rail
The two running rails that support the operation of the switch points. The straight stock rail is on the straight or through side of a lateral turnout. The bent stock rail or curved rail is on the diverging side of the turnout. The switch points fit securely against the stock rail to permit the transfer of wheel load from the stock rail to the switch point.

### Stock Rail Bend
The bend or set that must be given the stock rail to allow the switch point to follow the gage line on the turnout. Usually, only one stock rail of a turnout is bent. The opposite stock rail is straight.

### Stringlining
A method for determining the corrections to be made in the alignment of a curve, by measuring ordinates to the outer rail and without the use of surveying instruments.

### Sub-ballast
Any material of superior character, which is placed between the ballast and finished subgrade of the roadbed, to provide better drainage, prevent upheaval by frost and better distribution of the load to the roadbed.

### Subgrade
Natural materials, gravel or crushed rock, usually inferior to ballast or sub-ballast, placed in fills or at the bottom of cuts that lie directly below the sub-ballast and ballast.

### Superelevation
The height the outer rail raised above the inner or grade rail on curves to resist the centrifugal force of moving trains. This should not be confused with cross level on tangent (straight) track.

### Superelevation - Equilibrium
That elevation which exactly overcomes the effect of negotiating a curve at a given speed for any given degree of curvature, placing the resultant centrifugal force and weight of equipment in a direction perpendicular to the plane of the track.

### Superelevation – Reverse
See Reverse Elevation

### Surface - Track
The condition of a track as to vertical evenness or smoothness over short distances.

### Swing Bridge
A movable bridge that pivots around a pier in the center of the span, creating two navigation channels when open, one on each side of the center pier.

### Switch
A connection between two lines of track to permit flange wheeled rail vehicles to pass from one track to another.

### Switch - Insulated
A switch in which the fixtures, principally the gage plates and the switch rods connecting one rail to the other, are provided with insulation so that electric currents will not be shunted. Also, the turnout rail contains an insulating joint.

### Switch - Spiked/Clamped
A switch point that is secured in one position through the use of spikes, blacks and clamps.

### Switch - Staggered Point
A switch in which one point is placed in advance of the other. Used only in special design considerations.

### Switch - Throw of
The distance, measured along the centerline of the rod nearest the point connecting the two switch rails, through which switch points are moved sidewise to bring either point against its mating stock rail.

### Switch Heater
A device for melting snow with heat generated by an electric current, gas, oil or air. This device enables a switch to be thrown in inclement weather when there are accumulations of sleet, ice or snow.

### Switch Lock
A fastener, usually a spring padlock, used to secure the switch of derail stand in place and thus maintain correct position of these members.

### Switch Machine
The C&S appliance that powers and provides for the positive movement and locking of the switch rails and/or moveable point frog to permit the safe, uninterrupted movement of rail vehicles through a turnout.

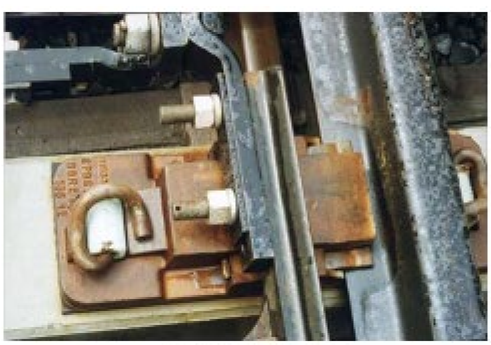
### Switch Machine Rod
The C&S operating (powered) rod that connects the switch machine to and moves the switch and/or frog point from normal to reverse position.

### Switch Machine Rod Basket
The appliance that connects the operating rod to the No. 1 tie rod in the switch or to the frog point lug of a moveable point frog. The basket can be reset to adjust the amount of throw occurring at the switch or frog point.

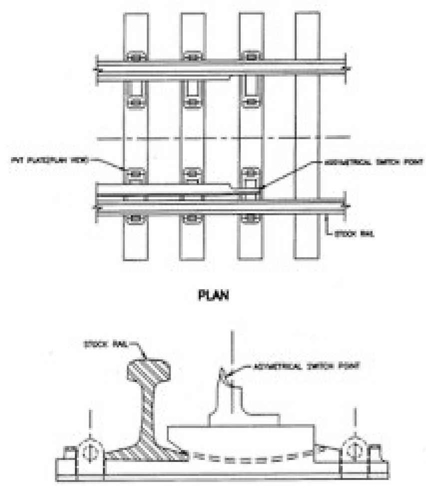
### Switch Obstruction Test
Test No. 13 as specified in C&S Procedure Number 27. This test is used as part of the criteria to determine if the switch points are properly fitting up against the straight and bent stock rails or if the moveable point of a moveable point frog fits against the MPF housing. This test ensures that the proper signal indication is being conveyed as the points move and are seated.

### Switch Plate
A special metal tie plate for use on switch ties, each plate being long enough to extend not only under the stock rail and its supporting braces, but also under the switch rail in open position. Switch plates are furnished in sets to correspond with switch length. There are two plates to each tie; however, at point of switch, the two may be replaced by a gage plate that carries both switch rails.

### Switch Plate - PVT
Plate Vertical Turnout - A type of high-profile switch plate used in some advance technology turnouts that uses two elastic clips to secure the stock rail to the switch plate.

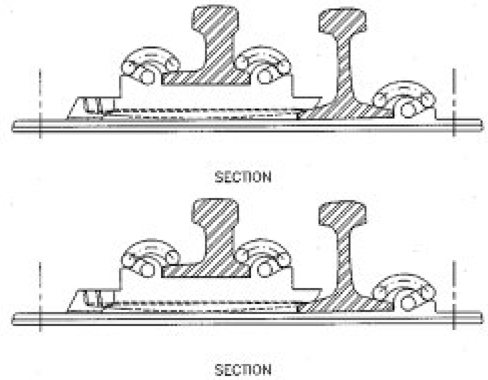


PVT Switch Plate



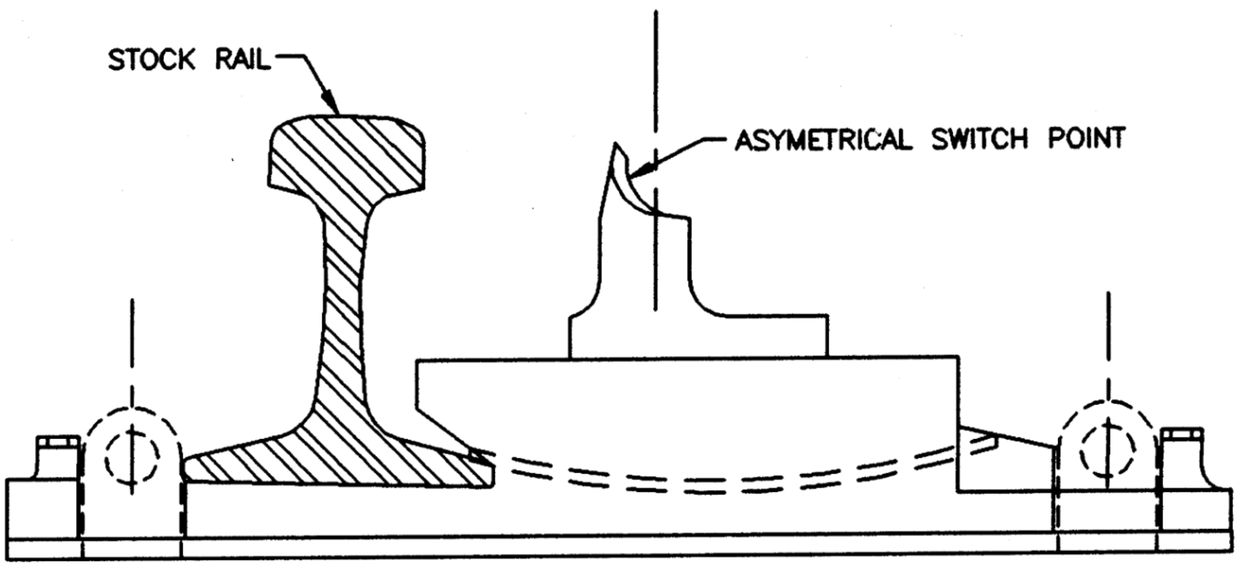

### Switch Plate - Schwihag
A type of high-profile plate used in some advance technology turnouts that uses a single elastic hairpin clip to secure the stock rail to the switch plate

Schwihag Switch Plate




## Switch  Point - Asymmetrical

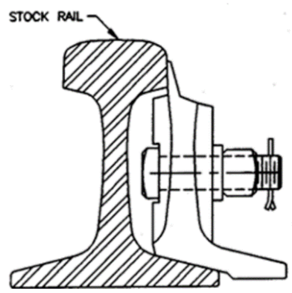
A switch point manufactured from a rail section that in cross section does not have the same shape or form about the center line through the end of the rail.



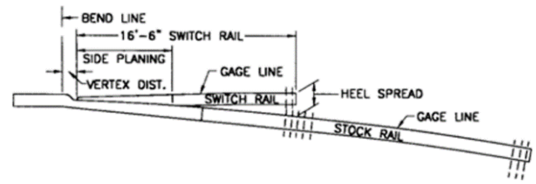

**Asymmetrical Switch Point Detail**

## Switch Point - Housed

The design makes use of a recessed vertical mating surface between the switch point and stock rail. The switch point is recessed behind the gage line of the rail. The "housing" of the switch point is achieved by vertical milling on the gage face of the stock rail



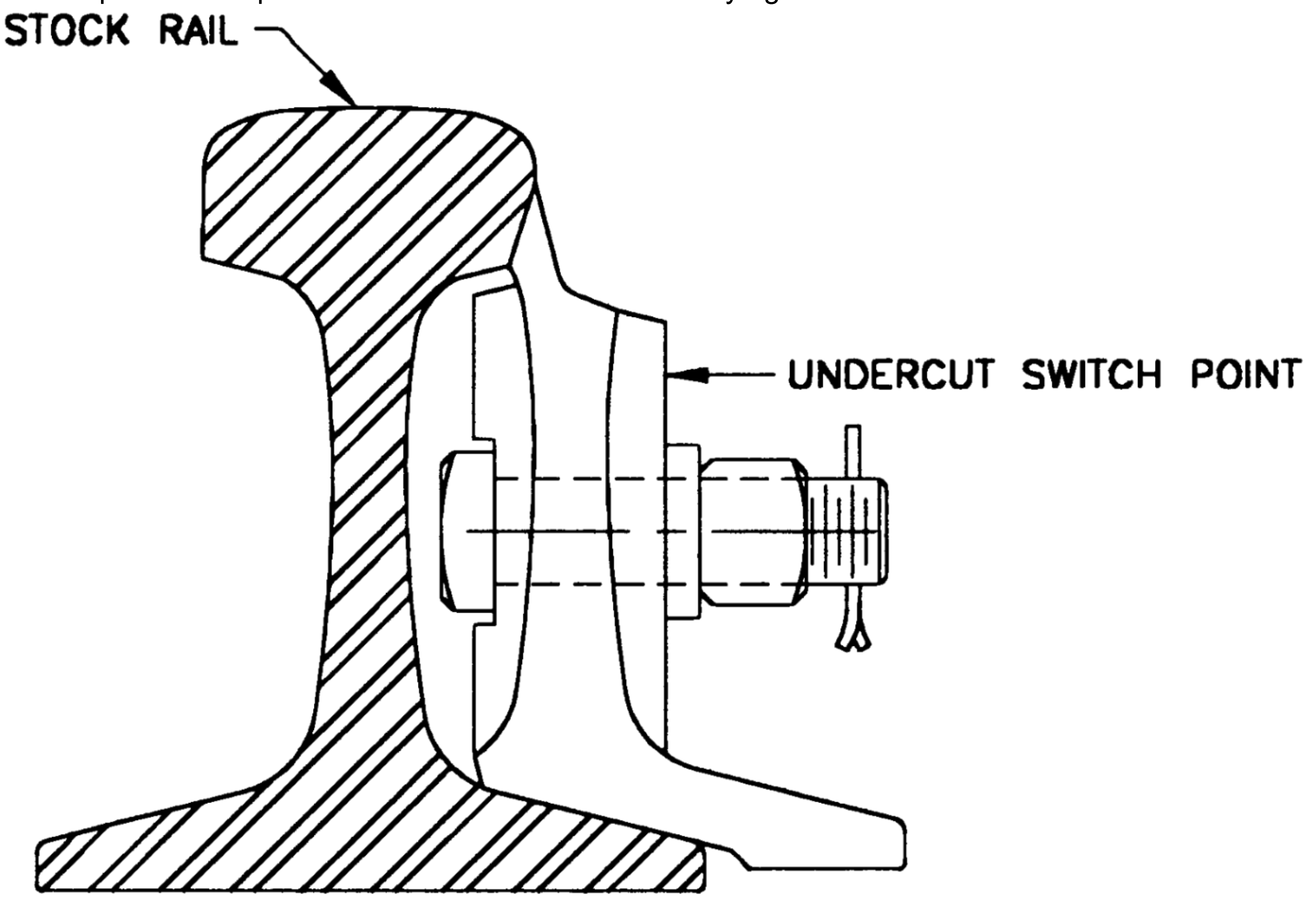

**Housed Switch Point**




**R.H. Straight Switch Point & Bent Stock Rail for a Housed Switch Point**

### Switch Point - Undercut

A switch point that is planed on the field side to fit securely against an undercut stock rail.



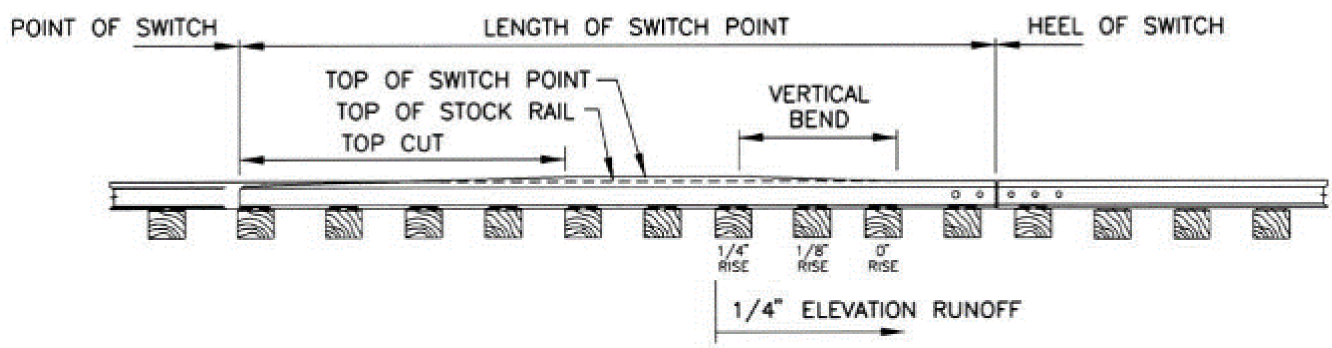

**Undercut Switch Point Detail**

### Switch Point Clips

The brackets used to connect switch rods to switch points

### Switch Point Guard

A structure made of rail or manganese steel secured to the field side of the running rail at the point of switch, with suitable flares to engage the tread rim of wheels and guide the wheel past the switch point. This appliance is intended to reduce or eliminate switch point contact and wear.




### Switch Point Lug
The lug attached to a switch point, to which the front rod is connected.

### Switch Point with Graduated Risers
A switch in which the switch rails are gradually elevated by means of graduated riser plates, until they reach the required height above a stock rail and sloping back to zero at the fixed heel block.

### Switch Point with Uniform Risers
A switch in which the switch rails have a uniform elevation on riser plates for the entire length of the switch, and therefore do not have a heel slope. The switch point rail rise is run off in back of the floating heel block.

### Switch Rail
The tapered rail of a switch.

### Switch Rod
A rod that connects the left hand and right hand switch point to ensure proper gage, alignment and adjustment throughout the switch.

### Switch Rod - Adjustable
A switch rod with an attachment for altering its length to keep the switch rails in their proper positions. Adjustment is usually effected through staggering holes in the clips that connect switch rod and switch rail.

### Switch Stand
A device by which a switch is thrown, locked, and its position indicated. It consists essentially of a base, spindle, lever, and connecting rod, together with target, and can be equipped with a lamp or banner. Unless described as "low" or "center throw", its target spindle extends 2' or more above top-of-rail elevation.

### Switch Target
A visual day signal fixed on the spindle of a switch stand, or the circular flaring collar fitted around the switch-lamp lens and painted a distinctive color to indicate the position of the switch.

## T

### Tension
An axial force or stress caused by equal and opposite forces pulling at the ends of the members. In simple bending it is also present above or below the neutral axis.

### Thermal Loading
The compressive forces generated in the rail due to its temperature being increased above its neutral temperature.

### Thimble
The cylindrical pieces of an insulating joint that surround portions of the bolts.

### Throat of Frog
The point at which the converging wings of a frog are closest together just ahead of frog point.

### Throw Rod
The operating rod attached to the Number 1 rod (the first rod) of a switch, connecting the switch to a switch stand or other operating device.

### Tie
A transverse support to which rails are fastened to keep them in line, gage and grade. Usually wooden or concrete.

### Tie - Center bound
Ballast condition where an unusually large percentage of the wheel load is carried at the center of the tie. This is an undesirable situation as compacted ballast under the rail seats should carry the load.

### Tie Plate
A metal plate at least 6" wide and long enough to provide a safe bearing area on the tie, with a shoulder to restrain outward movement of the rail.

### Tie Plate - Canted
A tie plate tapered in thickness usually on a slope of 1 in 40, for the purpose of inclining the rail toward the center of track for easier maintenance of gage, more uniform wear of head and central loading of rail.

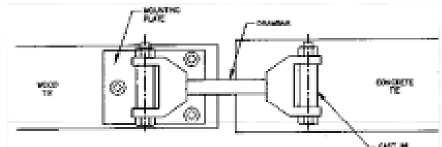
### Tie Plate - Twin
A tie plate in two parts that mate to form a combined width equal to that of the stand tie plate, for use back of the heel of switch to the point where standard tie plates may be applied without their ends infringing.

### Tie Plug
A wooden pin driven in to fill an unused spike hole in a tie, to exclude moisture, prevent decay, and provide solid wood for re-driving the spike. Usually supplied in the form of sticks containing several plugs; frequently of treated wood.

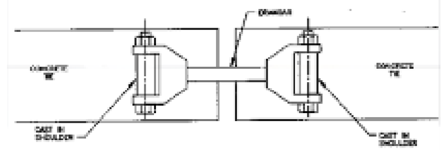
### Tie Spacing
The distances between tie centers in track or turnout.

### Tie Splice – Flexible (Dog Bone)
The mechanical connection to splice switch ties in a crossover. This device maintains the gage of the rails in the diverging side of the crossover where long and short switch ties meet but are not continuous. This device can be used to join wood, concrete, or wood to concrete switch ties.

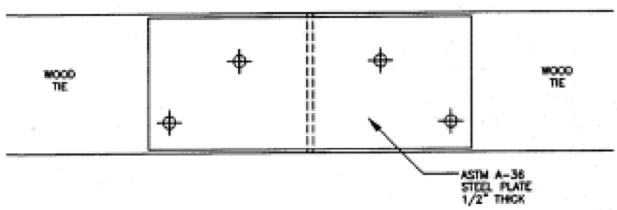
CONCRETE TO CONCRETE TIE SPLICE



CONCRETE TO WOOD TIE SPLICE



CONCRETE TO CONCRETE TIE SPLICE




WOOD TO WOOD TIE SPLICE

### Toe End of Frog
The end of a frog nearest the switch.

### Toe Spread
The distance between gage lines at the toe end of the frog.

### Tolerance
An allowance made for a small variation from dimensions specified.

### Track
The rail, ties, rail fastenings, hardware and roadbed between points not less than 4’ outside of each rail.

### Track – Disturbed
The disturbance of the roadbed or ballast section, as a result of track maintenance or any other event, which reduces the lateral or longitudinal resistance of the track, or both.

### Track – Skeletonized
Track with ballast removed from the cribs between ties.

### Track Breathing
The changing of the neutral temperature of CWR as a result of the natural cycle of seasonal temperature and the effect of the dynamic loading due to train operations.

### Track Buckling
The sudden formation of large lateral misalignments caused by high compressive forces, in the presence of some other influencing factors.

### Track Buckling Countermeasures
The performance of maintenance and construction work in CWR track in accordance with accepted procedures that maintain the stability of the track structure throughout a range of temperatures.

### Track Level
A board with a spirit level attached to level the rails of a track usually equipped with a series of steps to set superelevation on the outside rail of curves.

### Track Shim
A hardwood or fiber plate, generally as wide as the bearing of a standard tie plate but of a varying thickness, used to restore the running surface of track heaved by frost or otherwise distorted.

### Track Spike
A rectangular metal fastener with an elliptical head designed to secure tie, plates and/or rail to wood ties which is often called a cut spike.

### Traction Force
The longitudinal force induced into the rail as a result of effort of tractive effort of the locomotive and rolling of the wheels of all equipment.

### Trailing Point
A switch in which points face away from the normal direction of traffic. A trailing point move would pass over the frog and then the switch points.

### Train-induced Forces
The vertical, longitudinal, and lateral dynamic forces which are generated during train movement and which can contribute to the buckling potential.

### Transition Spiral
An easement curve from the tangent to the curve.

### Transpose Rail
Changing rail from one side to the other on curves because of headwear.

### Turnout (TO)
An arrangement of a switch and a frog with closure rails, by which rolling stock can be diverted from one track to another.

### Turnout – Advanced Technology
A turnout that contains tangential design with asymmetrical switch points and a moveable point frog or a conventional rail switch point with a new generation spring frog.

### Turnout – Conventional
A turnout whose transition from tangent to curve is not gradual because of alignment changes between the switch point and frog. These turnouts are usually constructed on wood ties, but can also be constructed on concrete ties. These turnouts usually have a “tee” rail switch point section and a self-guarded manganese (SGM) frog, welded heel manganese (WHM) frog, or rail bound manganese (RBM) frog.

### Turnout – Tangential
A turnout where the diverging route consists of a long smooth gradual curve between the point of switch and moveable point frog. In almost all cases, the tangential turnout has an asymmetric switch point. Increased diverging route speeds of 80 MPH are possible for the No. 32.75 turnouts. Lateral forces generated by vehicles in a tangential turnout are less than in a conventional turnout.

## U

### Underbalance (Cant Deficiency)

The difference between the actual superelevation and the amount of superelevation calculated for equilibrium conditions. Track underbalance is usually 3”. However, underbalance can be increased with the approval of the Chief Engineer-Track.

## V

### Vee Rail

The moveable point portion of a moveable point frog that lies between the wing rails. The "vee" rail is fixed on the heel end and it is free to move laterally at the point end. This rail permits the safe and continuous movement of wheels through a moveable point frog.

### Vertical Acceleration

The downward acceleration experienced by a rail vehicle that is perpendicular to the direction of travel. Vertical acceleration is a measure of ride quality and measured in units of ft./sec2 (g).

## W

### Warp-Short

Difference between any two actual level board readings (difference in cross level) 10' on spirals, tangents and full body of curves.

### Washer - Lock

A split spring washer also known as a nut lock.

### Washer - Spring

A spring tensioned member designed to prevent movement of a nut and looseness of a bolted member due to wear, stretch or other deterioration.

### Weld - Butt

A weld joining two abutting surfaces. This weld serves to unite the rail ends. Electric butt rail welding is accomplished with a stationary in-plant or electrical in-plant.

### Weld - Thermite

A weld joining two abutting surfaces with an intervening space. The weld serves to unite the abutting surfaces with the introduction of metal weldment. This process is accomplished by using easily handled weld kits.

### Wheel Tread

The flat or tapered surface of a railway wheel that contacts the top surface of the rail head.

### Wing Rail

The left and right rails that are run from the toe to the flared end of a moveable point frog (MPF), rail bound manganese frog (RBM), welded heel manganese frog (WHF), or spring frog.

## APPENDIX B UNDERBALANCE TABLES

## MAXIMUM ALLOWABLE OPERATING SPEED ON CURVES



Notes:

(a) The enclosed tables can be used to determine $V_{max}$ in accordance with §213.57 (FRA §213.329).

(b) The Assistant Chief Engineer-Track shall maintain a list of curves and the designated “underbalance” to be used.

(c) To operate at speeds which use “underbalance” greater than 3", the equipment must be qualified and approved by the Federal Railroad Administration.

(d) The maximum allowable operating speed for any degree of curvature, superelevation and underbalance given in these tables is 200 MPH.

Maximum Allowable Operating Speed on Curves

**Underbalance = 3" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0-0** | **0-1/4** | **0-1/2** | **0-3/4** | **1** | **1-1/4** | **1-1/2** | **1-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 160 | 166 | 173 | 179 | 185 | 190 | 196 | 200 |
| 0°-15' | 130 | 136 | 141 | 146 | 151 | 155 | 160 | 164 |
| 0°-20' | 113 | 118 | 122 | 126 | 130 | 134 | 138 | 142 |
| 0°-25' | 101 | 105 | 109 | 113 | 117 | 120 | 124 | 127 |
| 0°-30' | 92 | 96 | 100 | 103 | 106 | 110 | 113 | 116 |
| 0°-35' | 85 | 89 | 92 | 95 | 98 | 102 | 104 | 107 |
| 0°-40' | 80 | 83 | 86 | 89 | 92 | 95 | 98 | 100 |
| 0°-45' | 75 | 78 | 81 | 84 | 87 | 89 | 92 | 95 |
| 0°-50' | 71 | 74 | 77 | 80 | 82 | 85 | 87 | 90 |
| 0°-55' | 68 | 71 | 73 | 76 | 78 | 81 | 83 | 86 |
| 1°-00' | 65 | 68 | 70 | 73 | 75 | 77 | 80 | 82 |
| 1°-15' | 58 | 60 | 63 | 65 | 67 | 69 | 71 | 73 |
| 1°-30' | 53 | 55 | 57 | 59 | 61 | 63 | 65 | 67 |
| 1°-45' | 49 | 51 | 53 | 55 | 57 | 58 | 60 | 62 |
| 2°-00' | 46 | 48 | 50 | 51 | 53 | 55 | 56 | 58 |
| 2°-15' | 43 | 45 | 47 | 48 | 50 | 51 | 53 | 54 |
| 2°-30' | 41 | 43 | 44 | 46 | 47 | 49 | 50 | 52 |
| 2°-45' | 39 | 41 | 42 | 44 | 45 | 46 | 48 | 49 |
| 3°-00' | 37 | 39 | 40 | 42 | 43 | 44 | 46 | 47 |
| 3°-15' | 36 | 37 | 39 | 40 | 41 | 43 | 44 | 45 |
| 3°-30' | 34 | 36 | 37 | 39 | 40 | 41 | 42 | 44 |
| 3°-45' | 33 | 35 | 36 | 37 | 39 | 40 | 41 | 42 |
| 4°-00' | 32 | 34 | 35 | 36 | 37 | 38 | 40 | 41 |
| 4°-15' | 31 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| 4°-30' | 30 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |
| 4°-45' | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| 5°-00' | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| 5°-30' | 27 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| 6°-00' | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| 6°-30' | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 7°-00' | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 7°-30' | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 8°-00' | 23 | 24 | 25 | 25 | 26 | 27 | 28 | 29 |
| 8°-30' | 22 | 23 | 24 | 25 | 25 | 26 | 27 | 28 |
| 9°-00' | 21 | 22 | 23 | 24 | 25 | 25 | 26 | 27 |
| 9°-30' | 21 | 22 | 22 | 23 | 24 | 25 | 26 | 26 |
| 10°-00' | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 26 |
| 10°-30' | 20 | 21 | 21 | 22 | 23 | 24 | 24 | 25 |
| 11°-00' | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 |
| 11°-30' | 19 | 20 | 20 | 21 | 22 | 22 | 23 | 24 |
| 12°-00' | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 23 |
| 12°-30' | 18 | 19 | 20 | 20 | 21 | 22 | 22 | 23 |
| 13°-00' | 18 | 18 | 19 | 20 | 20 | 21 | 22 | 22 |
| 13°-30' | 17 | 18 | 19 | 19 | 20 | 21 | 21 | 22 |
| 14°-00' | 17 | 18 | 18 | 19 | 20 | 20 | 21 | 22 |
| 14°-30' | 17 | 17 | 18 | 19 | 19 | 20 | 21 | 21 |
| 15°-00' | 16 | 17 | 18 | 18 | 19 | 20 | 20 | 21 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves

**Underbalance = 3" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | **2** | **2-1/4** | **2-1/2** | **2-3/4** | **3** | **3-1/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 169 | 173 | 177 | 181 | 185 | 188 |
| 0°-20' | 146 | 149 | 153 | 156 | 160 | 163 |
| 0°-25' | 130 | 134 | 137 | 140 | 143 | 146 |
| 0°-30' | 119 | 122 | 125 | 128 | 130 | 133 |
| 0°-35' | 110 | 113 | 116 | 118 | 121 | 123 |
| 0°-40' | 103 | 106 | 108 | 111 | 113 | 115 |
| 0°-45' | 97 | 100 | 102 | 104 | 106 | 109 |
| 0°-50' | 92 | 94 | 97 | 99 | 101 | 103 |
| 0°-55' | 88 | 90 | 92 | 94 | 96 | 98 |
| 1°-00' | 84 | 86 | 88 | 90 | 92 | 94 |
| 1°-15' | 75 | 77 | 79 | 81 | 82 | 84 |
| 1°-30' | 69 | 70 | 72 | 74 | 75 | 77 |
| 1°-45' | 63 | 65 | 67 | 68 | 69 | 71 |
| 2°-00' | 59 | 61 | 62 | 64 | 65 | 66 |
| 2°-15' | 56 | 57 | 59 | 60 | 61 | 62 |
| 2°-30' | 53 | 54 | 56 | 57 | 58 | 59 |
| 2°-45' | 50 | 52 | 53 | 54 | 55 | 56 |
| 3°-00' | 48 | 50 | 51 | 52 | 53 | 54 |
| 3°-15' | 46 | 48 | 49 | 50 | 51 | 52 |
| 3°-30' | 45 | 46 | 47 | 48 | 49 | 50 |
| 3°-45' | 43 | 44 | 45 | 46 | 47 | 48 |
| 4°-00' | 42 | 43 | 44 | 45 | 46 | 47 |
| 4°-15' | 40 | 42 | 42 | 43 | 44 | 45 |
| 4°-30' | 39 | 40 | 41 | 42 | 43 | 44 |
| 4°-45' | 38 | 39 | 40 | 41 | 42 | 43 |
| 5°-00' | 37 | 38 | 39 | 40 | 41 | 42 |
| 5°-30' | 36 | 36 | 37 | 38 | 39 | 40 |
| 6°-00' | 34 | 35 | 36 | 37 | 37 | 38 |
| 6°-30' | 33 | 33 | 34 | 35 | 36 | 37 |
| 7°-00' | 31 | 32 | 33 | 34 | 34 | 35 |
| 7°-30' | 30 | 31 | 32 | 33 | 33 | 34 |
| 8°-00' | 29 | 30 | 31 | 32 | 32 | 33 |
| 8°-30' | 28 | 29 | 30 | 31 | 31 | 32 |
| 9°-00' | 28 | 28 | 29 | 30 | 30 | 31 |
| 9°-30' | 27 | 28 | 28 | 29 | 30 | 30 |
| 10°-00' | 26 | 27 | 28 | 28 | 29 | 29 |
| 10°-30' | 26 | 26 | 27 | 27 | 28 | 29 |
| 11°-00' | 25 | 26 | 26 | 27 | 27 | 28 |
| 11°-30' | 24 | 25 | 26 | 26 | 27 | 27 |
| 12°-00' | 24 | 25 | 25 | 26 | 26 | 27 |
| 12°-30' | 23 | 24 | 25 | 25 | 26 | 26 |
| 13°-00' | 23 | 24 | 24 | 25 | 25 | 26 |
| 13°-30' | 23 | 23 | 24 | 24 | 25 | 25 |
| 14°-00' | 22 | 23 | 23 | 24 | 24 | 25 |
| 14°-30' | 22 | 22 | 23 | 23 | 24 | 24 |
| 15°-00' | 21 | 22 | 22 | 23 | 23 | 24 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 3" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | **3-1/2** | **3-3/4** | **4** | **4-1/4** | **4-1/2** | **4-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 192 | 196 | 200 | 200 | 200 | 200 |
| 0°-20' | 166 | 170 | 173 | 176 | 179 | 182 |
| 0°-25' | 149 | 152 | 154 | 157 | 160 | 163 |
| 0°-30' | 136 | 138 | 141 | 143 | 146 | 148 |
| 0°-35' | 126 | 128 | 130 | 133 | 135 | 137 |
| 0°-40' | 118 | 120 | 122 | 124 | 126 | 128 |
| 0°-45' | 111 | 113 | 115 | 117 | 119 | 121 |
| 0°-50' | 105 | 107 | 109 | 111 | 113 | 115 |
| 0°-55' | 100 | 102 | 104 | 106 | 108 | 109 |
| 1°-00' | 96 | 98 | 100 | 101 | 103 | 105 |
| 1°-15' | 86 | 87 | 89 | 91 | 92 | 94 |
| 1°-30' | 78 | 80 | 81 | 83 | 84 | 85 |
| 1°-45' | 72 | 74 | 75 | 76 | 78 | 79 |
| 2°-00' | 68 | 69 | 70 | 71 | 73 | 74 |
| 2°-15' | 64 | 65 | 66 | 67 | 69 | 70 |
| 2°-30' | 60 | 62 | 63 | 64 | 65 | 66 |
| 2°-45' | 58 | 59 | 60 | 61 | 62 | 63 |
| 3°-00' | 55 | 56 | 57 | 58 | 59 | 60 |
| 3°-15' | 53 | 54 | 55 | 56 | 57 | 58 |
| 3°-30' | 51 | 52 | 53 | 54 | 55 | 56 |
| 3°-45' | 49 | 50 | 51 | 52 | 53 | 54 |
| 4°-00' | 48 | 49 | 50 | 50 | 51 | 52 |
| 4°-15' | 46 | 47 | 48 | 49 | 50 | 51 |
| 4°-30' | 45 | 46 | 47 | 47 | 48 | 49 |
| 4°-45' | 44 | 45 | 45 | 46 | 47 | 48 |
| 5°-00' | 43 | 43 | 44 | 45 | 46 | 47 |
| 5°-30' | 41 | 41 | 42 | 43 | 44 | 44 |
| 6°-00' | 39 | 40 | 40 | 41 | 42 | 42 |
| 6°-30' | 37 | 38 | 39 | 39 | 40 | 41 |
| 7°-00' | 36 | 37 | 37 | 38 | 39 | 39 |
| 7°-30' | 35 | 35 | 36 | 37 | 37 | 38 |
| 8°-00' | 34 | 34 | 35 | 35 | 36 | 37 |
| 8°-30' | 33 | 33 | 34 | 34 | 35 | 36 |
| 9°-00' | 32 | 32 | 33 | 33 | 34 | 35 |
| 9°-30' | 31 | 31 | 32 | 33 | 33 | 34 |
| 10°-00' | 30 | 31 | 31 | 32 | 32 | 33 |
| 10°-30' | 29 | 30 | 30 | 31 | 31 | 32 |
| 11°-00' | 29 | 29 | 30 | 30 | 31 | 31 |
| 11°-30' | 28 | 28 | 29 | 30 | 30 | 31 |
| 12°-00' | 27 | 28 | 28 | 29 | 29 | 30 |
| 12°-30' | 27 | 27 | 28 | 28 | 29 | 29 |
| 13°-00' | 26 | 27 | 27 | 28 | 28 | 29 |
| 13°-30' | 26 | 26 | 27 | 27 | 28 | 28 |
| 14°-00' | 25 | 26 | 26 | 27 | 27 | 28 |
| 14°-30' | 25 | 25 | 26 | 26 | 27 | 27 |
| 15°-00' | 24 | 25 | 25 | 26 | 26 | 27 |

NOTE: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves

**Underbalance = 3" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | |
|---|---|---|---|---|---|
| | **5** | **5-1/4** | **5-1/2** | **5-3/4** | **6** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 185 | 188 | 190 | 193 | 196 |
| 0°-25' | 165 | 168 | 170 | 173 | 175 |
| 0°-30' | 151 | 153 | 155 | 158 | 160 |
| 0°-35' | 139 | 142 | 144 | 146 | 148 |
| 0°-40' | 130 | 132 | 134 | 136 | 138 |
| 0°-45' | 123 | 125 | 127 | 129 | 130 |
| 0°-50' | 117 | 118 | 120 | 122 | 124 |
| 0°-55' | 111 | 113 | 115 | 116 | 118 |
| 1°-00' | 106 | 108 | 110 | 111 | 113 |
| 1°-15' | 95 | 97 | 98 | 100 | 101 |
| 1°-30' | 87 | 88 | 89 | 91 | 92 |
| 1°-45' | 80 | 82 | 83 | 84 | 85 |
| 2°-00' | 75 | 76 | 77 | 79 | 80 |
| 2°-15' | 71 | 72 | 73 | 74 | 75 |
| 2°-30' | 67 | 68 | 69 | 70 | 71 |
| 2°-45' | 64 | 65 | 66 | 67 | 68 |
| 3°-00' | 61 | 62 | 63 | 64 | 65 |
| 3°-15' | 59 | 60 | 61 | 62 | 62 |
| 3°-30' | 57 | 58 | 58 | 59 | 60 |
| 3°-45' | 55 | 56 | 56 | 57 | 58 |
| 4°-00' | 53 | 54 | 55 | 55 | 56 |
| 4°-15' | 51 | 52 | 53 | 54 | 55 |
| 4°-30' | 50 | 51 | 51 | 52 | 53 |
| 4°-45' | 49 | 49 | 50 | 51 | 52 |
| 5°-00' | 47 | 48 | 49 | 50 | 50 |
| 5°-30' | 45 | 46 | 46 | 47 | 48 |
| 6°-00' | 43 | 44 | 44 | 45 | 46 |
| 6°-30' | 41 | 42 | 43 | 43 | 44 |
| 7°-00' | 40 | 41 | 41 | 42 | 42 |
| 7°-30' | 39 | 39 | 40 | 40 | 41 |
| 8°-00' | 37 | 38 | 38 | 39 | 40 |
| 8°-30' | 36 | 37 | 37 | 38 | 38 |
| 9°-00' | 35 | 36 | 36 | 37 | 37 |
| 9°-30' | 34 | 35 | 35 | 36 | 36 |
| 10°-00' | 33 | 34 | 34 | 35 | 35 |
| 10°-30' | 32 | 33 | 34 | 34 | 34 |
| 11°-00' | 32 | 32 | 33 | 33 | 34 |
| 11°-30' | 31 | 32 | 32 | 32 | 33 |
| 12°-00' | 30 | 31 | 31 | 32 | 32 |
| 12°-30' | 30 | 30 | 31 | 31 | 32 |
| 13°-00' | 29 | 30 | 30 | 31 | 31 |
| 13°-30' | 29 | 29 | 29 | 30 | 30 |
| 14°-00' | 28 | 29 | 29 | 29 | 30 |
| 14°-30' | 28 | 28 | 28 | 29 | 29 |
| 15°-00' | 27 | 28 | 28 | 28 | 29 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 4" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0-0 | 0-1/4 | 0-1/2 | 0-3/4 | 1 | 1-1/4 | 1-1/2 | 1-3/4 |
| Curvature (D) | Speed in Miles Per Hour (Vmax) | | | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 185 | 190 | 196 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 151 | 155 | 160 | 164 | 169 | 173 | 177 | 181 |
| 0°-20' | 130 | 134 | 138 | 142 | 146 | 149 | 153 | 156 |
| 0°-25' | 117 | 120 | 124 | 127 | 130 | 134 | 137 | 140 |
| 0°-30' | 106 | 110 | 113 | 116 | 119 | 122 | 125 | 128 |
| 0°-35' | 98 | 102 | 104 | 107 | 110 | 113 | 116 | 118 |
| 0°-40' | 92 | 95 | 98 | 100 | 103 | 106 | 108 | 111 |
| 0°-45' | 87 | 89 | 92 | 95 | 97 | 100 | 102 | 104 |
| 0°-50' | 82 | 85 | 87 | 90 | 92 | 94 | 97 | 99 |
| 0°-55' | 78 | 81 | 83 | 86 | 88 | 90 | 92 | 94 |
| 1°-00' | 75 | 77 | 80 | 82 | 84 | 86 | 88 | 90 |
| 1°-15' | 67 | 69 | 71 | 73 | 75 | 77 | 79 | 81 |
| 1°-30' | 61 | 63 | 65 | 67 | 69 | 70 | 72 | 74 |
| 1°-45' | 57 | 58 | 60 | 62 | 63 | 65 | 67 | 68 |
| 2°-00' | 53 | 55 | 56 | 58 | 59 | 61 | 62 | 64 |
| 2°-15' | 50 | 51 | 53 | 54 | 56 | 57 | 59 | 60 |
| 2°-30' | 47 | 49 | 50 | 52 | 53 | 54 | 56 | 57 |
| 2°-45' | 45 | 46 | 48 | 49 | 50 | 52 | 53 | 54 |
| 3°-00' | 43 | 44 | 46 | 47 | 48 | 50 | 51 | 52 |
| 3°-15' | 41 | 43 | 44 | 45 | 46 | 48 | 49 | 50 |
| 3°-30' | 40 | 41 | 42 | 44 | 45 | 46 | 47 | 48 |
| 3°-45' | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
| 4°-00' | 37 | 38 | 40 | 41 | 42 | 43 | 44 | 45 |
| 4°-15' | 36 | 37 | 38 | 39 | 40 | 42 | 42 | 43 |
| 4°-30' | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
| 4°-45' | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
| 5°-00' | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 5°-30' | 32 | 33 | 34 | 35 | 36 | 36 | 37 | 38 |
| 6°-00' | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| 6°-30' | 29 | 30 | 31 | 32 | 33 | 33 | 34 | 35 |
| 7°-00' | 28 | 29 | 30 | 31 | 31 | 32 | 33 | 34 |
| 7°-30' | 27 | 28 | 29 | 30 | 30 | 31 | 32 | 33 |
| 8°-00' | 26 | 27 | 28 | 29 | 29 | 30 | 31 | 32 |
| 8°-30' | 25 | 26 | 27 | 28 | 28 | 29 | 30 | 31 |
| 9°-00' | 25 | 25 | 26 | 27 | 28 | 28 | 29 | 30 |
| 9°-30' | 24 | 25 | 26 | 26 | 27 | 28 | 28 | 29 |
| 10°-00' | 23 | 24 | 25 | 26 | 26 | 27 | 28 | 28 |
| 10°-30' | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 |
| 11°-00' | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 |
| 11°-30' | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 |
| 12°-00' | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 |
| 12°-30' | 21 | 22 | 22 | 23 | 23 | 24 | 25 | 25 |
| 13°-00' | 20 | 21 | 22 | 22 | 23 | 24 | 24 | 25 |
| 13°-30' | 20 | 21 | 21 | 22 | 23 | 23 | 24 | 24 |
| 14°-00' | 20 | 20 | 21 | 22 | 22 | 23 | 23 | 24 |
| 14°-30' | 19 | 20 | 21 | 21 | 22 | 22 | 23 | 23 |
| 15°-00' | 19 | 20 | 20 | 21 | 21 | 22 | 22 | 23 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves

**Underbalance = 4" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | **2** | **2-1/4** | **2-1/2** | **2-3/4** | **3** | **3-1/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 185 | 188 | 192 | 196 | 200 | 200 |
| 0°-20' | 160 | 163 | 166 | 170 | 173 | 176 |
| 0°-25' | 143 | 146 | 149 | 152 | 154 | 157 |
| 0°-30' | 130 | 133 | 136 | 138 | 141 | 143 |
| 0°-35' | 121 | 123 | 126 | 128 | 130 | 133 |
| 0°-40' | 113 | 115 | 118 | 120 | 122 | 124 |
| 0°-45' | 106 | 109 | 111 | 113 | 115 | 117 |
| 0°-50' | 101 | 103 | 105 | 107 | 109 | 111 |
| 0°-55' | 96 | 98 | 100 | 102 | 104 | 106 |
| 1°-00' | 92 | 94 | 96 | 98 | 100 | 101 |
| 1°-15' | 82 | 84 | 86 | 87 | 89 | 91 |
| 1°-30' | 75 | 77 | 78 | 80 | 81 | 83 |
| 1°-45' | 69 | 71 | 72 | 74 | 75 | 76 |
| 2°-00' | 65 | 66 | 68 | 69 | 70 | 71 |
| 2°-15' | 61 | 62 | 64 | 65 | 66 | 67 |
| 2°-30' | 58 | 59 | 60 | 62 | 63 | 64 |
| 2°-45' | 55 | 56 | 58 | 59 | 60 | 61 |
| 3°-00' | 53 | 54 | 55 | 56 | 57 | 58 |
| 3°-15' | 51 | 52 | 53 | 54 | 55 | 56 |
| 3°-30' | 49 | 50 | 51 | 52 | 53 | 54 |
| 3°-45' | 47 | 48 | 49 | 50 | 51 | 52 |
| 4°-00' | 46 | 47 | 48 | 49 | 50 | 50 |
| 4°-15' | 44 | 45 | 46 | 47 | 48 | 49 |
| 4°-30' | 43 | 44 | 45 | 46 | 47 | 47 |
| 4°-45' | 42 | 43 | 44 | 45 | 45 | 46 |
| 5°-00' | 41 | 42 | 43 | 43 | 44 | 45 |
| 5°-30' | 39 | 40 | 41 | 41 | 42 | 43 |
| 6°-00' | 37 | 38 | 39 | 40 | 40 | 41 |
| 6°-30' | 36 | 37 | 37 | 38 | 39 | 39 |
| 7°-00' | 34 | 35 | 36 | 37 | 37 | 38 |
| 7°-30' | 33 | 34 | 35 | 35 | 36 | 37 |
| 8°-00' | 32 | 33 | 34 | 34 | 35 | 35 |
| 8°-30' | 31 | 32 | 33 | 33 | 34 | 34 |
| 9°-00' | 30 | 31 | 32 | 32 | 33 | 33 |
| 9°-30' | 30 | 30 | 31 | 31 | 32 | 33 |
| 10°-00' | 29 | 29 | 30 | 31 | 31 | 32 |
| 10°-30' | 28 | 29 | 29 | 30 | 30 | 31 |
| 11°-00' | 27 | 28 | 29 | 29 | 30 | 30 |
| 11°-30' | 27 | 27 | 28 | 28 | 29 | 30 |
| 12°-00' | 26 | 27 | 27 | 28 | 28 | 29 |
| 12°-30' | 26 | 26 | 27 | 27 | 28 | 28 |
| 13°-00' | 25 | 26 | 26 | 27 | 27 | 28 |
| 13°-30' | 25 | 25 | 26 | 26 | 27 | 27 |
| 14°-00' | 24 | 25 | 25 | 26 | 26 | 27 |
| 14°-30' | 24 | 24 | 25 | 25 | 26 | 26 |
| 15°-00' | 23 | 24 | 24 | 25 | 25 | 26 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves

**Underbalance = 4" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | **3-1/2** | **3-3/4** | **4** | **4-1/4** | **4-1/2** | **4-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 179 | 182 | 185 | 188 | 190 | 193 |
| 0°-25' | 160 | 163 | 165 | 168 | 170 | 173 |
| 0°-30' | 146 | 148 | 151 | 153 | 155 | 158 |
| 0°-35' | 135 | 137 | 139 | 142 | 144 | 146 |
| 0°-40' | 126 | 128 | 130 | 132 | 134 | 136 |
| 0°-45' | 119 | 121 | 123 | 125 | 127 | 129 |
| 0°-50' | 113 | 115 | 117 | 118 | 120 | 122 |
| 0°-55' | 108 | 109 | 111 | 113 | 115 | 116 |
| 1°-00' | 103 | 105 | 106 | 108 | 110 | 111 |
| 1°-15' | 92 | 94 | 95 | 97 | 98 | 100 |
| 1°-30' | 84 | 85 | 87 | 88 | 89 | 91 |
| 1°-45' | 78 | 79 | 80 | 82 | 83 | 84 |
| 2°-00' | 73 | 74 | 75 | 76 | 77 | 79 |
| 2°-15' | 69 | 70 | 71 | 72 | 73 | 74 |
| 2°-30' | 65 | 66 | 67 | 68 | 69 | 70 |
| 2°-45' | 62 | 63 | 64 | 65 | 66 | 67 |
| 3°-00' | 59 | 60 | 61 | 62 | 63 | 64 |
| 3°-15' | 57 | 58 | 59 | 60 | 61 | 62 |
| 3°-30' | 55 | 56 | 57 | 58 | 58 | 59 |
| 3°-45' | 53 | 54 | 55 | 56 | 56 | 57 |
| 4°-00' | 51 | 52 | 53 | 54 | 55 | 55 |
| 4°-15' | 50 | 51 | 51 | 52 | 53 | 54 |
| 4°-30' | 48 | 49 | 50 | 51 | 51 | 52 |
| 4°-45' | 47 | 48 | 49 | 49 | 50 | 51 |
| 5°-00' | 46 | 47 | 47 | 48 | 49 | 50 |
| 5°-30' | 44 | 44 | 45 | 46 | 46 | 47 |
| 6°-00' | 42 | 42 | 43 | 44 | 44 | 45 |
| 6°-30' | 40 | 41 | 41 | 42 | 43 | 43 |
| 7°-00' | 39 | 39 | 40 | 41 | 41 | 42 |
| 7°-30' | 37 | 38 | 39 | 39 | 40 | 40 |
| 8°-00' | 36 | 37 | 37 | 38 | 38 | 39 |
| 8°-30' | 35 | 36 | 36 | 37 | 37 | 38 |
| 9°-00' | 34 | 35 | 35 | 36 | 36 | 37 |
| 9°-30' | 33 | 34 | 34 | 35 | 35 | 36 |
| 10°-00' | 32 | 33 | 33 | 34 | 34 | 35 |
| 10°-30' | 31 | 32 | 32 | 33 | 34 | 34 |
| 11°-00' | 31 | 31 | 32 | 32 | 33 | 33 |
| 11°-30' | 30 | 31 | 31 | 32 | 32 | 32 |
| 12°-00' | 29 | 30 | 30 | 31 | 31 | 32 |
| 12°-30' | 29 | 29 | 30 | 30 | 31 | 31 |
| 13°-00' | 28 | 29 | 29 | 30 | 30 | 31 |
| 13°-30' | 28 | 28 | 29 | 29 | 29 | 30 |
| 14°-00' | 27 | 28 | 28 | 29 | 29 | 29 |
| 14°-30' | 27 | 27 | 28 | 28 | 28 | 29 |
| 15°-00' | 26 | 27 | 27 | 28 | 28 | 28 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 4" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | |
|---|---|---|---|---|---|
| | **5** | **5-1/4** | **5-1/2** | **5-3/4** | **6** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 196 | 199 | 200 | 200 | 200 |
| 0°-25' | 175 | 178 | 180 | 182 | 185 |
| 0°-30' | 160 | 162 | 164 | 166 | 169 |
| 0°-35' | 148 | 150 | 152 | 154 | 156 |
| 0°-40' | 138 | 140 | 142 | 144 | 146 |
| 0°-45' | 130 | 132 | 134 | 136 | 138 |
| 0°-50' | 124 | 125 | 127 | 129 | 130 |
| 0°-55' | 118 | 120 | 121 | 123 | 124 |
| 1°-00' | 113 | 114 | 116 | 118 | 119 |
| 1°-15' | 101 | 102 | 104 | 105 | 106 |
| 1°-30' | 92 | 93 | 95 | 96 | 97 |
| 1°-45' | 85 | 86 | 88 | 89 | 90 |
| 2°-00' | 80 | 81 | 82 | 83 | 84 |
| 2°-15' | 75 | 76 | 77 | 78 | 79 |
| 2°-30' | 71 | 72 | 73 | 74 | 75 |
| 2°-45' | 68 | 69 | 70 | 71 | 72 |
| 3°-00' | 65 | 66 | 67 | 68 | 69 |
| 3°-15' | 62 | 63 | 64 | 65 | 66 |
| 3°-30' | 60 | 61 | 62 | 63 | 63 |
| 3°-45' | 58 | 59 | 60 | 60 | 61 |
| 4°-00' | 56 | 57 | 58 | 59 | 59 |
| 4°-15' | 55 | 55 | 56 | 57 | 57 |
| 4°-30' | 53 | 54 | 54 | 55 | 56 |
| 4°-45' | 52 | 52 | 53 | 54 | 54 |
| 5°-00' | 50 | 51 | 52 | 52 | 53 |
| 5°-30' | 48 | 49 | 49 | 50 | 50 |
| 6°-00' | 46 | 46 | 47 | 48 | 48 |
| 6°-30' | 44 | 45 | 45 | 46 | 46 |
| 7°-00' | 42 | 43 | 44 | 44 | 45 |
| 7°-30' | 41 | 41 | 42 | 43 | 43 |
| 8°-00' | 40 | 40 | 41 | 41 | 42 |
| 8°-30' | 38 | 39 | 39 | 40 | 40 |
| 9°-00' | 37 | 38 | 38 | 39 | 39 |
| 9°-30' | 36 | 37 | 37 | 38 | 38 |
| 10°-00' | 35 | 36 | 36 | 37 | 37 |
| 10°-30' | 34 | 35 | 35 | 36 | 36 |
| 11°-00' | 34 | 34 | 35 | 35 | 36 |
| 11°-30' | 33 | 33 | 34 | 34 | 35 |
| 12°-00' | 32 | 33 | 33 | 34 | 34 |
| 12°-30' | 32 | 32 | 32 | 33 | 33 |
| 13°-00' | 31 | 31 | 32 | 32 | 33 |
| 13°-30' | 30 | 31 | 31 | 32 | 32 |
| 14°-00' | 30 | 30 | 31 | 31 | 31 |
| 14°-30' | 29 | 30 | 30 | 30 | 31 |
| 15°-00' | 29 | 29 | 30 | 30 | 30 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves

**Underbalance = 5" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0-0** | **0-1/4** | **0-1/2** | **0-3/4** | **1** | **1-1/4** | **1-1/2** | **1-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 169 | 173 | 177 | 181 | 185 | 188 | 192 | 196 |
| 0°-20' | 146 | 149 | 153 | 156 | 160 | 163 | 166 | 170 |
| 0°-25' | 130 | 134 | 137 | 140 | 143 | 146 | 149 | 152 |
| 0°-30' | 119 | 122 | 125 | 128 | 130 | 133 | 136 | 138 |
| 0°-35' | 110 | 113 | 116 | 118 | 121 | 123 | 126 | 128 |
| 0°-40' | 103 | 106 | 108 | 111 | 113 | 115 | 118 | 120 |
| 0°-45' | 97 | 100 | 102 | 104 | 106 | 109 | 111 | 113 |
| 0°-50' | 92 | 94 | 97 | 99 | 101 | 103 | 105 | 107 |
| 0°-55' | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 |
| 1°-00' | 84 | 86 | 88 | 90 | 92 | 94 | 96 | 98 |
| 1°-15' | 75 | 77 | 79 | 81 | 82 | 84 | 86 | 87 |
| 1°-30' | 69 | 70 | 72 | 74 | 75 | 77 | 78 | 80 |
| 1°-45' | 63 | 65 | 67 | 68 | 69 | 71 | 72 | 74 |
| 2°-00' | 59 | 61 | 62 | 64 | 65 | 66 | 68 | 69 |
| 2°-15' | 56 | 57 | 59 | 60 | 61 | 62 | 64 | 65 |
| 2°-30' | 53 | 54 | 56 | 57 | 58 | 59 | 60 | 62 |
| 2°-45' | 50 | 52 | 53 | 54 | 55 | 56 | 58 | 59 |
| 3°-00' | 48 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| 3°-15' | 46 | 48 | 49 | 50 | 51 | 52 | 53 | 54 |
| 3°-30' | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 |
| 3°-45' | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| 4°-00' | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
| 4°-15' | 40 | 42 | 42 | 43 | 44 | 45 | 46 | 47 |
| 4°-30' | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
| 4°-45' | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| 5°-00' | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 43 |
| 5°-30' | 36 | 36 | 37 | 38 | 39 | 40 | 41 | 41 |
| 6°-00' | 34 | 35 | 36 | 37 | 37 | 38 | 39 | 40 |
| 6°-30' | 33 | 33 | 34 | 35 | 36 | 37 | 37 | 38 |
| 7°-00' | 31 | 32 | 33 | 34 | 34 | 35 | 36 | 37 |
| 7°-30' | 30 | 31 | 32 | 33 | 33 | 34 | 35 | 35 |
| 8°-00' | 29 | 30 | 31 | 32 | 32 | 33 | 34 | 34 |
| 8°-30' | 28 | 29 | 30 | 31 | 31 | 32 | 33 | 33 |
| 9°-00' | 28 | 28 | 29 | 30 | 30 | 31 | 32 | 32 |
| 9°-30' | 27 | 28 | 28 | 29 | 30 | 30 | 31 | 31 |
| 10°-00' | 26 | 27 | 28 | 28 | 29 | 29 | 30 | 31 |
| 10°-30' | 26 | 26 | 27 | 27 | 28 | 29 | 29 | 30 |
| 11°-00' | 25 | 26 | 26 | 27 | 27 | 28 | 29 | 29 |
| 11°-30' | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 28 |
| 12°-00' | 24 | 25 | 25 | 26 | 26 | 27 | 27 | 28 |
| 12°-30' | 23 | 24 | 25 | 25 | 26 | 26 | 27 | 27 |
| 13°-00' | 23 | 24 | 24 | 25 | 25 | 26 | 26 | 27 |
| 13°-30' | 23 | 23 | 24 | 24 | 25 | 25 | 26 | 26 |
| 14°-00' | 22 | 23 | 23 | 24 | 24 | 25 | 25 | 26 |
| 14°-30' | 22 | 22 | 23 | 23 | 24 | 24 | 25 | 25 |
| 15°-00' | 21 | 22 | 22 | 23 | 23 | 24 | 24 | 25 |

Note: All curves under 0º-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 5" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 2-1/4 | 2-1/2 | 2-3/4 | 3 | 3-1/4 |
| Curvature (D) | Speed in Miles Per Hour (Vmax) | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 173 | 176 | 179 | 182 | 185 | 188 |
| 0°-25' | 154 | 157 | 160 | 163 | 165 | 168 |
| 0°-30' | 141 | 143 | 146 | 148 | 151 | 153 |
| 0°-35' | 130 | 133 | 135 | 137 | 139 | 142 |
| 0°-40' | 122 | 124 | 126 | 128 | 130 | 132 |
| 0°-45' | 115 | 117 | 119 | 121 | 123 | 125 |
| 0°-50' | 109 | 111 | 113 | 115 | 117 | 118 |
| 0°-55' | 104 | 106 | 108 | 109 | 111 | 113 |
| 1°-00' | 100 | 101 | 103 | 105 | 106 | 108 |
| 1°-15' | 89 | 91 | 92 | 94 | 95 | 97 |
| 1°-30' | 81 | 83 | 84 | 85 | 87 | 88 |
| 1°-45' | 75 | 76 | 78 | 79 | 80 | 82 |
| 2°-00' | 70 | 71 | 73 | 74 | 75 | 76 |
| 2°-15' | 66 | 67 | 69 | 70 | 71 | 72 |
| 2°-30' | 63 | 64 | 65 | 66 | 67 | 68 |
| 2°-45' | 60 | 61 | 62 | 63 | 64 | 65 |
| 3°-00' | 57 | 58 | 59 | 60 | 61 | 62 |
| 3°-15' | 55 | 56 | 57 | 58 | 59 | 60 |
| 3°-30' | 53 | 54 | 55 | 56 | 57 | 58 |
| 3°-45' | 51 | 52 | 53 | 54 | 55 | 56 |
| 4°-00' | 50 | 50 | 51 | 52 | 53 | 54 |
| 4°-15' | 48 | 49 | 50 | 51 | 51 | 52 |
| 4°-30' | 47 | 47 | 48 | 49 | 50 | 51 |
| 4°-45' | 45 | 46 | 47 | 48 | 49 | 49 |
| 5°-00' | 44 | 45 | 46 | 47 | 47 | 48 |
| 5°-30' | 42 | 43 | 44 | 44 | 45 | 46 |
| 6°-00' | 40 | 41 | 42 | 42 | 43 | 44 |
| 6°-30' | 39 | 39 | 40 | 41 | 41 | 42 |
| 7°-00' | 37 | 38 | 39 | 39 | 40 | 41 |
| 7°-30' | 36 | 37 | 37 | 38 | 39 | 39 |
| 8°-00' | 35 | 35 | 36 | 37 | 37 | 38 |
| 8°-30' | 34 | 34 | 35 | 36 | 36 | 37 |
| 9°-00' | 33 | 33 | 34 | 35 | 35 | 36 |
| 9°-30' | 32 | 33 | 33 | 34 | 34 | 35 |
| 10°-00' | 31 | 32 | 32 | 33 | 33 | 34 |
| 10°-30' | 30 | 31 | 31 | 32 | 32 | 33 |
| 11°-00' | 30 | 30 | 31 | 31 | 32 | 32 |
| 11°-30' | 29 | 30 | 30 | 31 | 31 | 32 |
| 12°-00' | 28 | 29 | 29 | 30 | 30 | 31 |
| 12°-30' | 28 | 28 | 29 | 29 | 30 | 30 |
| 13°-00' | 27 | 28 | 28 | 29 | 29 | 30 |
| 13°-30' | 27 | 27 | 28 | 28 | 29 | 29 |
| 14°-00' | 26 | 27 | 27 | 28 | 28 | 29 |
| 14°-30' | 26 | 26 | 27 | 27 | 28 | 28 |
| 15°-00' | 25 | 26 | 26 | 27 | 27 | 28 |

Note: All curves under 0° -20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 5" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | 3-1/2 | 3-3/4 | 4 | 4-1/4 | 4-1/2 | 4-3/4 |
| Curvature (D) | Speed in Miles Per Hour (Vmax) | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 190 | 193 | 196 | 199 | 200 | 200 |
| 0°-25' | 170 | 173 | 175 | 178 | 180 | 182 |
| 0°-30' | 155 | 158 | 160 | 162 | 164 | 166 |
| 0°-35' | 144 | 146 | 148 | 150 | 152 | 154 |
| 0°-40' | 134 | 136 | 138 | 140 | 142 | 144 |
| 0°-45' | 127 | 129 | 130 | 132 | 134 | 136 |
| 0°-50' | 120 | 122 | 124 | 125 | 127 | 129 |
| 0°-55' | 115 | 116 | 118 | 120 | 121 | 123 |
| 1°-00' | 110 | 111 | 113 | 114 | 116 | 118 |
| 1°-15' | 98 | 100 | 101 | 102 | 104 | 105 |
| 1°-30' | 89 | 91 | 92 | 93 | 95 | 96 |
| 1°-45' | 83 | 84 | 85 | 86 | 88 | 89 |
| 2°-00' | 77 | 79 | 80 | 81 | 82 | 83 |
| 2°-15' | 73 | 74 | 75 | 76 | 77 | 78 |
| 2°-30' | 69 | 70 | 71 | 72 | 73 | 74 |
| 2°-45' | 66 | 67 | 68 | 69 | 70 | 71 |
| 3°-00' | 63 | 64 | 65 | 66 | 67 | 68 |
| 3°-15' | 61 | 62 | 62 | 63 | 64 | 65 |
| 3°-30' | 58 | 59 | 60 | 61 | 62 | 63 |
| 3°-45' | 56 | 57 | 58 | 59 | 60 | 60 |
| 4°-00' | 55 | 55 | 56 | 57 | 58 | 59 |
| 4°-15' | 53 | 54 | 55 | 55 | 56 | 57 |
| 4°-30' | 51 | 52 | 53 | 54 | 54 | 55 |
| 4°-45' | 50 | 51 | 52 | 52 | 53 | 54 |
| 5°-00' | 49 | 50 | 50 | 51 | 52 | 52 |
| 5°-30' | 46 | 47 | 48 | 49 | 49 | 50 |
| 6°-00' | 44 | 45 | 46 | 46 | 47 | 48 |
| 6°-30' | 43 | 43 | 44 | 45 | 45 | 46 |
| 7°-00' | 41 | 42 | 42 | 43 | 44 | 44 |
| 7°-30' | 40 | 40 | 41 | 41 | 42 | 43 |
| 8°-00' | 38 | 39 | 40 | 40 | 41 | 41 |
| 8°-30' | 37 | 38 | 38 | 39 | 39 | 40 |
| 9°-00' | 36 | 37 | 37 | 38 | 38 | 39 |
| 9°-30' | 35 | 36 | 36 | 37 | 37 | 38 |
| 10°-00' | 34 | 35 | 35 | 36 | 36 | 37 |
| 10°-30' | 34 | 34 | 34 | 35 | 35 | 36 |
| 11°-00' | 33 | 33 | 34 | 34 | 35 | 35 |
| 11°-30' | 32 | 32 | 33 | 33 | 34 | 34 |
| 12°-00' | 31 | 32 | 32 | 33 | 33 | 34 |
| 12°-30' | 31 | 31 | 32 | 32 | 32 | 33 |
| 13°-00' | 30 | 31 | 31 | 31 | 32 | 32 |
| 13°-30' | 29 | 30 | 30 | 31 | 31 | 32 |
| 14°-00' | 29 | 29 | 30 | 30 | 31 | 31 |
| 14°-30' | 28 | 29 | 29 | 30 | 30 | 30 |
| 15°-00' | 28 | 28 | 29 | 29 | 30 | 30 |

Note: All curves under 0° -20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves

**Underbalance = 5" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | |
|---|---|---|---|---|---|
| | **5** | **5-1/4** | **5-1/2** | **5-3/4** | **6** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 185 | 187 | 189 | 191 | 194 |
| 0°-30' | 169 | 171 | 173 | 175 | 177 |
| 0°-35' | 156 | 158 | 160 | 162 | 164 |
| 0°-40' | 146 | 148 | 149 | 151 | 153 |
| 0°-45' | 138 | 139 | 141 | 143 | 144 |
| 0°-50' | 130 | 132 | 134 | 135 | 137 |
| 0°-55' | 124 | 126 | 127 | 129 | 130 |
| 1°-00' | 119 | 121 | 122 | 123 | 125 |
| 1°-15' | 106 | 108 | 109 | 110 | 112 |
| 1°-30' | 97 | 98 | 100 | 101 | 102 |
| 1°-45' | 90 | 91 | 92 | 93 | 94 |
| 2°-00' | 84 | 85 | 86 | 87 | 88 |
| 2°-15' | 79 | 80 | 81 | 82 | 83 |
| 2°-30' | 75 | 76 | 77 | 78 | 79 |
| 2°-45' | 72 | 72 | 73 | 74 | 75 |
| 3°-00' | 69 | 69 | 70 | 71 | 72 |
| 3°-15' | 66 | 67 | 67 | 68 | 69 |
| 3°-30' | 63 | 64 | 65 | 66 | 67 |
| 3°-45' | 61 | 62 | 63 | 63 | 64 |
| 4°-00' | 59 | 60 | 61 | 61 | 62 |
| 4°-15' | 57 | 58 | 59 | 60 | 60 |
| 4°-30' | 56 | 57 | 57 | 58 | 59 |
| 4°-45' | 54 | 55 | 56 | 56 | 57 |
| 5°-00' | 53 | 54 | 54 | 55 | 56 |
| 5°-30' | 50 | 51 | 52 | 52 | 53 |
| 6°-00' | 48 | 49 | 50 | 50 | 51 |
| 6°-30' | 46 | 47 | 48 | 48 | 49 |
| 7°-00' | 45 | 45 | 46 | 46 | 47 |
| 7°-30' | 43 | 44 | 44 | 45 | 45 |
| 8°-00' | 42 | 42 | 43 | 43 | 44 |
| 8°-30' | 40 | 41 | 42 | 42 | 42 |
| 9°-00' | 39 | 40 | 40 | 41 | 41 |
| 9°-30' | 38 | 39 | 39 | 40 | 40 |
| 10°-00' | 37 | 38 | 38 | 39 | 39 |
| 10°-30' | 36 | 37 | 37 | 38 | 38 |
| 11°-00' | 36 | 36 | 36 | 37 | 37 |
| 11°-30' | 35 | 35 | 36 | 36 | 36 |
| 12°-00' | 34 | 34 | 35 | 35 | 36 |
| 12°-30' | 33 | 34 | 34 | 35 | 35 |
| 13°-00' | 33 | 33 | 33 | 34 | 34 |
| 13°-30' | 32 | 32 | 33 | 33 | 34 |
| 14°-00' | 31 | 32 | 32 | 33 | 33 |
| 14°-30' | 31 | 31 | 32 | 32 | 32 |
| 15°-00' | 30 | 31 | 31 | 31 | 32 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 6" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0-0** | **0-1/4** | **0-1/2** | **0-3/4** | **1** | **1-1/4** | **1-1/2** | **1-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 185 | 188 | 192 | 196 | 200 | 200 | 200 | 200 |
| 0°-20' | 160 | 163 | 166 | 170 | 173 | 176 | 179 | 182 |
| 0°-25' | 143 | 146 | 149 | 152 | 154 | 157 | 160 | 163 |
| 0°-30' | 130 | 133 | 136 | 138 | 141 | 143 | 146 | 148 |
| 0°-35' | 121 | 123 | 126 | 128 | 130 | 133 | 135 | 137 |
| 0°-40' | 113 | 115 | 118 | 120 | 122 | 124 | 126 | 128 |
| 0°-45' | 106 | 109 | 111 | 113 | 115 | 117 | 119 | 121 |
| 0°-50' | 101 | 103 | 105 | 107 | 109 | 111 | 113 | 115 |
| 0°-55' | 96 | 98 | 100 | 102 | 104 | 106 | 108 | 109 |
| 1°-00' | 92 | 94 | 96 | 98 | 100 | 101 | 103 | 105 |
| 1°-15' | 82 | 84 | 86 | 87 | 89 | 91 | 92 | 94 |
| 1°-30' | 75 | 77 | 78 | 80 | 81 | 83 | 84 | 85 |
| 1°-45' | 69 | 71 | 72 | 74 | 75 | 76 | 78 | 79 |
| 2°-00' | 65 | 66 | 68 | 69 | 70 | 71 | 73 | 74 |
| 2°-15' | 61 | 62 | 64 | 65 | 66 | 67 | 69 | 70 |
| 2°-30' | 58 | 59 | 60 | 62 | 63 | 64 | 65 | 66 |
| 2°-45' | 55 | 56 | 58 | 59 | 60 | 61 | 62 | 63 |
| 3°-00' | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 3°-15' | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
| 3°-30' | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| 3°-45' | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 |
| 4°-00' | 46 | 47 | 48 | 49 | 50 | 50 | 51 | 52 |
| 4°-15' | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 |
| 4°-30' | 43 | 44 | 45 | 46 | 47 | 47 | 48 | 49 |
| 4°-45' | 42 | 43 | 44 | 45 | 45 | 46 | 47 | 48 |
| 5°-00' | 41 | 42 | 43 | 43 | 44 | 45 | 46 | 47 |
| 5°-30' | 39 | 40 | 41 | 41 | 42 | 43 | 44 | 44 |
| 6°-00' | 37 | 38 | 39 | 40 | 40 | 41 | 42 | 42 |
| 6°-30' | 36 | 37 | 37 | 38 | 39 | 39 | 40 | 41 |
| 7°-00' | 34 | 35 | 36 | 37 | 37 | 38 | 39 | 39 |
| 7°-30' | 33 | 34 | 35 | 35 | 36 | 37 | 37 | 38 |
| 8°-00' | 32 | 33 | 34 | 34 | 35 | 35 | 36 | 37 |
| 8°-30' | 31 | 32 | 33 | 33 | 34 | 34 | 35 | 36 |
| 9°-00' | 30 | 31 | 32 | 32 | 33 | 33 | 34 | 35 |
| 9°-30' | 30 | 30 | 31 | 31 | 32 | 33 | 33 | 34 |
| 10°-00' | 29 | 29 | 30 | 31 | 31 | 32 | 32 | 33 |
| 10°-30' | 28 | 29 | 29 | 30 | 30 | 31 | 31 | 32 |
| 11°-00' | 27 | 28 | 29 | 29 | 30 | 30 | 31 | 31 |
| 11°-30' | 27 | 27 | 28 | 28 | 29 | 30 | 30 | 31 |
| 12°-00' | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 |
| 12°-30' | 26 | 26 | 27 | 27 | 28 | 28 | 29 | 29 |
| 13°-00' | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 29 |
| 13°-30' | 25 | 25 | 26 | 26 | 27 | 27 | 28 | 28 |
| 14°-00' | 24 | 25 | 25 | 26 | 26 | 27 | 27 | 28 |
| 14°-30' | 24 | 24 | 25 | 25 | 26 | 26 | 27 | 27 |
| 15°-00' | 23 | 24 | 24 | 25 | 25 | 26 | 26 | 27 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 6" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 2-1/4 | 2-1/2 | 2-3/4 | 3 | 3-1/4 |
| Curvature (D) | Speed in Miles Per Hour (Vmax) | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 185 | 188 | 190 | 193 | 196 | 199 |
| 0°-25' | 165 | 168 | 170 | 173 | 175 | 178 |
| 0°-30' | 151 | 153 | 155 | 158 | 160 | 162 |
| 0°-35' | 139 | 142 | 144 | 146 | 148 | 150 |
| 0°-40' | 130 | 132 | 134 | 136 | 138 | 140 |
| 0°-45' | 123 | 125 | 127 | 129 | 130 | 132 |
| 0°-50' | 117 | 118 | 120 | 122 | 124 | 125 |
| 0°-55' | 111 | 113 | 115 | 116 | 118 | 120 |
| 1°-00' | 106 | 108 | 110 | 111 | 113 | 114 |
| 1°-15' | 95 | 97 | 98 | 100 | 101 | 102 |
| 1°-30' | 87 | 88 | 89 | 91 | 92 | 93 |
| 1°-45' | 80 | 82 | 83 | 84 | 85 | 86 |
| 2°-00' | 75 | 76 | 77 | 79 | 80 | 81 |
| 2°-15' | 71 | 72 | 73 | 74 | 75 | 76 |
| 2°-30' | 67 | 68 | 69 | 70 | 71 | 72 |
| 2°-45' | 64 | 65 | 66 | 67 | 68 | 69 |
| 3°-00' | 61 | 62 | 63 | 64 | 65 | 66 |
| 3°-15' | 59 | 60 | 61 | 62 | 62 | 63 |
| 3°-30' | 57 | 58 | 58 | 59 | 60 | 61 |
| 3°-45' | 55 | 56 | 56 | 57 | 58 | 59 |
| 4°-00' | 53 | 54 | 55 | 55 | 56 | 57 |
| 4°-15' | 51 | 52 | 53 | 54 | 55 | 55 |
| 4°-30' | 50 | 51 | 51 | 52 | 53 | 54 |
| 4°-45' | 49 | 49 | 50 | 51 | 52 | 52 |
| 5°-00' | 47 | 48 | 49 | 50 | 50 | 51 |
| 5°-30' | 45 | 46 | 46 | 47 | 48 | 49 |
| 6°-00' | 43 | 44 | 44 | 45 | 46 | 46 |
| 6°-30' | 41 | 42 | 43 | 43 | 44 | 45 |
| 7°-00' | 40 | 41 | 41 | 42 | 42 | 43 |
| 7°-30' | 39 | 39 | 40 | 40 | 41 | 41 |
| 8°-00' | 37 | 38 | 38 | 39 | 40 | 40 |
| 8°-30' | 36 | 37 | 37 | 38 | 38 | 39 |
| 9°-00' | 35 | 36 | 36 | 37 | 37 | 38 |
| 9°-30' | 34 | 35 | 35 | 36 | 36 | 37 |
| 10°-00' | 33 | 34 | 34 | 35 | 35 | 36 |
| 10°-30' | 32 | 33 | 34 | 34 | 34 | 35 |
| 11°-00' | 32 | 32 | 33 | 33 | 34 | 34 |
| 11°-30' | 31 | 32 | 32 | 32 | 33 | 33 |
| 12°-00' | 30 | 31 | 31 | 32 | 32 | 33 |
| 12°-30' | 30 | 30 | 31 | 31 | 32 | 32 |
| 13°-00' | 29 | 30 | 30 | 31 | 31 | 31 |
| 13°-30' | 29 | 29 | 29 | 30 | 30 | 31 |
| 14°-00' | 28 | 29 | 29 | 29 | 30 | 30 |
| 14°-30' | 28 | 28 | 28 | 29 | 29 | 30 |
| 15°-00' | 27 | 28 | 28 | 28 | 29 | 29 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 6" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | 3-1/2 | 3-3/4 | 4 | 4-1/4 | 4-1/2 | 4-3/4 |
| Curvature (D) | Speed in Miles Per Hour (Vmax) | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 180 | 182 | 185 | 187 | 189 | 191 |
| 0°-30' | 164 | 166 | 169 | 171 | 173 | 175 |
| 0°-35' | 152 | 154 | 156 | 158 | 160 | 162 |
| 0°-40' | 142 | 144 | 146 | 148 | 149 | 151 |
| 0°-45' | 134 | 136 | 138 | 139 | 141 | 143 |
| 0°-50' | 127 | 129 | 130 | 132 | 134 | 135 |
| 0°-55' | 121 | 123 | 124 | 126 | 127 | 129 |
| 1°-00' | 116 | 118 | 119 | 121 | 122 | 123 |
| 1°-15' | 104 | 105 | 106 | 108 | 109 | 110 |
| 1°-30' | 95 | 96 | 97 | 98 | 100 | 101 |
| 1°-45' | 88 | 89 | 90 | 91 | 92 | 93 |
| 2°-00' | 82 | 83 | 84 | 85 | 86 | 87 |
| 2°-15' | 77 | 78 | 79 | 80 | 81 | 82 |
| 2°-30' | 73 | 74 | 75 | 76 | 77 | 78 |
| 2°-45' | 70 | 71 | 72 | 72 | 73 | 74 |
| 3°-00' | 67 | 68 | 69 | 69 | 70 | 71 |
| 3°-15' | 64 | 65 | 66 | 67 | 67 | 68 |
| 3°-30' | 62 | 63 | 63 | 64 | 65 | 66 |
| 3°-45' | 60 | 60 | 61 | 62 | 63 | 63 |
| 4°-00' | 58 | 59 | 59 | 60 | 61 | 61 |
| 4°-15' | 56 | 57 | 57 | 58 | 59 | 60 |
| 4°-30' | 54 | 55 | 56 | 57 | 57 | 58 |
| 4°-45' | 53 | 54 | 54 | 55 | 56 | 56 |
| 5°-00' | 52 | 52 | 53 | 54 | 54 | 55 |
| 5°-30' | 49 | 50 | 50 | 51 | 52 | 52 |
| 6°-00' | 47 | 48 | 48 | 49 | 50 | 50 |
| 6°-30' | 45 | 46 | 46 | 47 | 48 | 48 |
| 7°-00' | 44 | 44 | 45 | 45 | 46 | 46 |
| 7°-30' | 42 | 43 | 43 | 44 | 44 | 45 |
| 8°-00' | 41 | 41 | 42 | 42 | 43 | 43 |
| 8°-30' | 39 | 40 | 40 | 41 | 42 | 42 |
| 9°-00' | 38 | 39 | 39 | 40 | 40 | 41 |
| 9°-30' | 37 | 38 | 38 | 39 | 39 | 40 |
| 10°-00' | 36 | 37 | 37 | 38 | 38 | 39 |
| 10°-30' | 35 | 36 | 36 | 37 | 37 | 38 |
| 11°-00' | 35 | 35 | 36 | 36 | 36 | 37 |
| 11°-30' | 34 | 34 | 35 | 35 | 36 | 36 |
| 12°-00' | 33 | 34 | 34 | 34 | 35 | 35 |
| 12°-30' | 32 | 33 | 33 | 34 | 34 | 35 |
| 13°-00' | 32 | 32 | 33 | 33 | 33 | 34 |
| 13°-30' | 31 | 32 | 32 | 32 | 33 | 33 |
| 14°-00' | 31 | 31 | 31 | 32 | 32 | 33 |
| 14°-30' | 30 | 30 | 31 | 31 | 32 | 32 |
| 15°-00' | 30 | 30 | 30 | 31 | 31 | 31 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 6" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | |
|---|---|---|---|---|---|
| | **5** | **5-1/4** | **5-1/2** | **5-3/4** | **6** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 194 | 196 | 198 | 200 | 200 |
| 0°-30' | 177 | 179 | 181 | 183 | 185 |
| 0°-35' | 164 | 165 | 167 | 169 | 171 |
| 0°-40' | 153 | 155 | 156 | 158 | 160 |
| 0°-45' | 144 | 146 | 148 | 149 | 151 |
| 0°-50' | 137 | 138 | 140 | 141 | 143 |
| 0°-55' | 130 | 132 | 133 | 135 | 136 |
| 1°-00' | 125 | 126 | 128 | 129 | 130 |
| 1°-15' | 112 | 113 | 114 | 115 | 117 |
| 1°-30' | 102 | 103 | 104 | 105 | 106 |
| 1°-45' | 94 | 95 | 96 | 97 | 98 |
| 2°-00' | 88 | 89 | 90 | 91 | 92 |
| 2°-15' | 83 | 84 | 85 | 86 | 87 |
| 2°-30' | 79 | 80 | 81 | 81 | 82 |
| 2°-45' | 75 | 76 | 77 | 78 | 78 |
| 3°-00' | 72 | 73 | 74 | 74 | 75 |
| 3°-15' | 69 | 70 | 71 | 71 | 72 |
| 3°-30' | 67 | 67 | 68 | 69 | 69 |
| 3°-45' | 64 | 65 | 66 | 66 | 67 |
| 4°-00' | 62 | 63 | 64 | 64 | 65 |
| 4°-15' | 60 | 61 | 62 | 62 | 63 |
| 4°-30' | 59 | 59 | 60 | 61 | 61 |
| 4°-45' | 57 | 58 | 58 | 59 | 60 |
| 5°-00' | 56 | 56 | 57 | 57 | 58 |
| 5°-30' | 53 | 54 | 54 | 55 | 55 |
| 6°-00' | 51 | 51 | 52 | 52 | 53 |
| 6°-30' | 49 | 49 | 50 | 50 | 51 |
| 7°-00' | 47 | 47 | 48 | 48 | 49 |
| 7°-30' | 45 | 46 | 46 | 47 | 47 |
| 8°-00' | 44 | 44 | 45 | 45 | 46 |
| 8°-30' | 42 | 43 | 43 | 44 | 44 |
| 9°-00' | 41 | 42 | 42 | 43 | 43 |
| 9°-30' | 40 | 41 | 41 | 42 | 42 |
| 10°-00' | 39 | 40 | 40 | 40 | 41 |
| 10°-30' | 38 | 39 | 39 | 39 | 40 |
| 11°-00' | 37 | 38 | 38 | 39 | 39 |
| 11°-30' | 36 | 37 | 37 | 38 | 38 |
| 12°-00' | 36 | 36 | 37 | 37 | 37 |
| 12°-30' | 35 | 35 | 36 | 36 | 37 |
| 13°-00' | 34 | 35 | 35 | 35 | 36 |
| 13°-30' | 34 | 34 | 34 | 35 | 35 |
| 14°-00' | 33 | 33 | 34 | 34 | 34 |
| 14°-30' | 32 | 33 | 33 | 34 | 34 |
| 15°-00' | 32 | 32 | 33 | 33 | 33 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves

**Underbalance = 7" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0-0** | **0-1/4** | **0-1/2** | **0-3/4** | **1** | **1-1/4** | **1-1/2** | **1-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 173 | 176 | 179 | 182 | 185 | 188 | 190 | 193 |
| 0°-25' | 154 | 157 | 160 | 163 | 165 | 168 | 170 | 173 |
| 0°-30' | 141 | 143 | 146 | 148 | 151 | 153 | 155 | 158 |
| 0°-35' | 130 | 133 | 135 | 137 | 139 | 142 | 144 | 146 |
| 0°-40' | 122 | 124 | 126 | 128 | 130 | 132 | 134 | 136 |
| 0°-45' | 115 | 117 | 119 | 121 | 123 | 125 | 127 | 129 |
| 0°-50' | 109 | 111 | 113 | 115 | 117 | 118 | 120 | 122 |
| 0°-55' | 104 | 106 | 108 | 109 | 111 | 113 | 115 | 116 |
| 1°-00' | 100 | 101 | 103 | 105 | 106 | 108 | 110 | 111 |
| 1°-15' | 89 | 91 | 92 | 94 | 95 | 97 | 98 | 100 |
| 1°-30' | 81 | 83 | 84 | 85 | 87 | 88 | 89 | 91 |
| 1°-45' | 75 | 76 | 78 | 79 | 80 | 82 | 83 | 84 |
| 2°-00' | 70 | 71 | 73 | 74 | 75 | 76 | 77 | 79 |
| 2°-15' | 66 | 67 | 69 | 70 | 71 | 72 | 73 | 74 |
| 2°-30' | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 2°-45' | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 |
| 3°-00' | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| 3°-15' | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 |
| 3°-30' | 53 | 54 | 55 | 56 | 57 | 58 | 58 | 59 |
| 3°-45' | 51 | 52 | 53 | 54 | 55 | 56 | 56 | 57 |
| 4°-00' | 50 | 50 | 51 | 52 | 53 | 54 | 55 | 55 |
| 4°-15' | 48 | 49 | 50 | 51 | 51 | 52 | 53 | 54 |
| 4°-30' | 47 | 47 | 48 | 49 | 50 | 51 | 51 | 52 |
| 4°-45' | 45 | 46 | 47 | 48 | 49 | 49 | 50 | 51 |
| 5°-00' | 44 | 45 | 46 | 47 | 47 | 48 | 49 | 50 |
| 5°-30' | 42 | 43 | 44 | 44 | 45 | 46 | 46 | 47 |
| 6°-00' | 40 | 41 | 42 | 42 | 43 | 44 | 44 | 45 |
| 6°-30' | 39 | 39 | 40 | 41 | 41 | 42 | 43 | 43 |
| 7°-00' | 37 | 38 | 39 | 39 | 40 | 41 | 41 | 42 |
| 7°-30' | 36 | 37 | 37 | 38 | 39 | 39 | 40 | 40 |
| 8°-00' | 35 | 35 | 36 | 37 | 37 | 38 | 38 | 39 |
| 8°-30' | 34 | 34 | 35 | 36 | 36 | 37 | 37 | 38 |
| 9°-00' | 33 | 33 | 34 | 35 | 35 | 36 | 36 | 37 |
| 9°-30' | 32 | 33 | 33 | 34 | 34 | 35 | 35 | 36 |
| 10°-00' | 31 | 32 | 32 | 33 | 33 | 34 | 34 | 35 |
| 10°-30' | 30 | 31 | 31 | 32 | 32 | 33 | 34 | 34 |
| 11°-00' | 30 | 30 | 31 | 31 | 32 | 32 | 33 | 33 |
| 11°-30' | 29 | 30 | 30 | 31 | 31 | 32 | 32 | 32 |
| 12°-00' | 28 | 29 | 29 | 30 | 30 | 31 | 31 | 32 |
| 12°-30' | 28 | 28 | 29 | 29 | 30 | 30 | 31 | 31 |
| 13°-00' | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 |
| 13°-30' | 27 | 27 | 28 | 28 | 29 | 29 | 29 | 30 |
| 14°-00' | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 29 |
| 14°-30' | 26 | 26 | 27 | 27 | 28 | 28 | 28 | 29 |
| 15°-00' | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 28 |

Note: All curves under 0º-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 7" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 2-1/4 | 2-1/2 | 2-3/4 | 3 | 3-1/4 |
| Curvature (D) | Speed in Miles Per Hour (Vmax) | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 196 | 199 | 200 | 200 | 200 | 200 |
| 0°-25' | 175 | 178 | 180 | 182 | 185 | 187 |
| 0°-30' | 160 | 162 | 164 | 166 | 169 | 171 |
| 0°-35' | 148 | 150 | 152 | 154 | 156 | 158 |
| 0°-40' | 138 | 140 | 142 | 144 | 146 | 148 |
| 0°-45' | 130 | 132 | 134 | 136 | 138 | 139 |
| 0°-50' | 124 | 125 | 127 | 129 | 130 | 132 |
| 0°-55' | 118 | 120 | 121 | 123 | 124 | 126 |
| 1°-00' | 113 | 114 | 116 | 118 | 119 | 121 |
| 1°-15' | 101 | 102 | 104 | 105 | 106 | 108 |
| 1°-30' | 92 | 93 | 95 | 96 | 97 | 98 |
| 1°-45' | 85 | 86 | 88 | 89 | 90 | 91 |
| 2°-00' | 80 | 81 | 82 | 83 | 84 | 85 |
| 2°-15' | 75 | 76 | 77 | 78 | 79 | 80 |
| 2°-30' | 71 | 72 | 73 | 74 | 75 | 76 |
| 2°-45' | 68 | 69 | 70 | 71 | 72 | 72 |
| 3°-00' | 65 | 66 | 67 | 68 | 69 | 69 |
| 3°-15' | 62 | 63 | 64 | 65 | 66 | 67 |
| 3°-30' | 60 | 61 | 62 | 63 | 63 | 64 |
| 3°-45' | 58 | 59 | 60 | 60 | 61 | 62 |
| 4°-00' | 56 | 57 | 58 | 59 | 59 | 60 |
| 4°-15' | 55 | 55 | 56 | 57 | 57 | 58 |
| 4°-30' | 53 | 54 | 54 | 55 | 56 | 57 |
| 4°-45' | 52 | 52 | 53 | 54 | 54 | 55 |
| 5°-00' | 50 | 51 | 52 | 52 | 53 | 54 |
| 5°-30' | 48 | 49 | 49 | 50 | 50 | 51 |
| 6°-00' | 46 | 46 | 47 | 48 | 48 | 49 |
| 6°-30' | 44 | 45 | 45 | 46 | 46 | 47 |
| 7°-00' | 42 | 43 | 44 | 44 | 45 | 45 |
| 7°-30' | 41 | 41 | 42 | 43 | 43 | 44 |
| 8°-00' | 40 | 40 | 41 | 41 | 42 | 42 |
| 8°-30' | 38 | 39 | 39 | 40 | 40 | 41 |
| 9°-00' | 37 | 38 | 38 | 39 | 39 | 40 |
| 9°-30' | 36 | 37 | 37 | 38 | 38 | 39 |
| 10°-00' | 35 | 36 | 36 | 37 | 37 | 38 |
| 10°-30' | 34 | 35 | 35 | 36 | 36 | 37 |
| 11°-00' | 34 | 34 | 35 | 35 | 36 | 36 |
| 11°-30' | 33 | 33 | 34 | 34 | 35 | 35 |
| 12°-00' | 32 | 33 | 33 | 34 | 34 | 34 |
| 12°-30' | 32 | 32 | 32 | 33 | 33 | 34 |
| 13°-00' | 31 | 31 | 32 | 32 | 33 | 33 |
| 13°-30' | 30 | 31 | 31 | 32 | 32 | 32 |
| 14°-00' | 30 | 30 | 31 | 31 | 31 | 32 |
| 14°-30' | 29 | 30 | 30 | 30 | 31 | 31 |
| 15°-00' | 29 | 29 | 30 | 30 | 30 | 31 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 7" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | **3-1/2** | **3-3/4** | **4** | **4-1/4** | **4-1/2** | **4-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 189 | 191 | 194 | 196 | 198 | 200 |
| 0°-30' | 173 | 175 | 177 | 179 | 181 | 183 |
| 0°-35' | 160 | 162 | 164 | 165 | 167 | 169 |
| 0°-40' | 149 | 151 | 153 | 155 | 156 | 158 |
| 0°-45' | 141 | 143 | 144 | 146 | 148 | 149 |
| 0°-50' | 134 | 135 | 137 | 138 | 140 | 141 |
| 0°-55' | 127 | 129 | 130 | 132 | 133 | 135 |
| 1°-00' | 122 | 123 | 125 | 126 | 128 | 129 |
| 1°-15' | 109 | 110 | 112 | 113 | 114 | 115 |
| 1°-30' | 100 | 101 | 102 | 103 | 104 | 105 |
| 1°-45' | 92 | 93 | 94 | 95 | 96 | 97 |
| 2°-00' | 86 | 87 | 88 | 89 | 90 | 91 |
| 2°-15' | 81 | 82 | 83 | 84 | 85 | 86 |
| 2°-30' | 77 | 78 | 79 | 80 | 81 | 81 |
| 2°-45' | 73 | 74 | 75 | 76 | 77 | 78 |
| 3°-00' | 70 | 71 | 72 | 73 | 74 | 74 |
| 3°-15' | 67 | 68 | 69 | 70 | 71 | 71 |
| 3°-30' | 65 | 66 | 67 | 67 | 68 | 69 |
| 3°-45' | 63 | 63 | 64 | 65 | 66 | 66 |
| 4°-00' | 61 | 61 | 62 | 63 | 64 | 64 |
| 4°-15' | 59 | 60 | 60 | 61 | 62 | 62 |
| 4°-30' | 57 | 58 | 59 | 59 | 60 | 61 |
| 4°-45' | 56 | 56 | 57 | 58 | 58 | 59 |
| 5°-00' | 54 | 55 | 56 | 56 | 57 | 57 |
| 5°-30' | 52 | 52 | 53 | 54 | 54 | 55 |
| 6°-00' | 50 | 50 | 51 | 51 | 52 | 52 |
| 6°-30' | 48 | 48 | 49 | 49 | 50 | 50 |
| 7°-00' | 46 | 46 | 47 | 47 | 48 | 48 |
| 7°-30' | 44 | 45 | 45 | 46 | 46 | 47 |
| 8°-00' | 43 | 43 | 44 | 44 | 45 | 45 |
| 8°-30' | 42 | 42 | 42 | 43 | 43 | 44 |
| 9°-00' | 40 | 41 | 41 | 42 | 42 | 43 |
| 9°-30' | 39 | 40 | 40 | 41 | 41 | 42 |
| 10°-00' | 38 | 39 | 39 | 40 | 40 | 40 |
| 10°-30' | 37 | 38 | 38 | 39 | 39 | 39 |
| 11°-00' | 36 | 37 | 37 | 38 | 38 | 39 |
| 11°-30' | 36 | 36 | 36 | 37 | 37 | 38 |
| 12°-00' | 35 | 35 | 36 | 36 | 37 | 37 |
| 12°-30' | 34 | 35 | 35 | 35 | 36 | 36 |
| 13°-00' | 33 | 34 | 34 | 35 | 35 | 35 |
| 13°-30' | 33 | 33 | 34 | 34 | 34 | 35 |
| 14°-00' | 32 | 33 | 33 | 33 | 34 | 34 |
| 14°-30' | 32 | 32 | 32 | 33 | 33 | 34 |
| 15°-00' | 31 | 31 | 32 | 32 | 33 | 33 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 7" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | |
|---|---|---|---|---|---|
| | **5** | **5-1/4** | **5-1/2** | **5-3/4** | **6** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 200 | 200 | 200 | 200 | 200 |
| 0°-30' | 185 | 187 | 188 | 190 | 192 |
| 0°-35' | 171 | 173 | 174 | 176 | 178 |
| 0°-40' | 160 | 162 | 163 | 165 | 166 |
| 0°-45' | 151 | 152 | 154 | 155 | 157 |
| 0°-50' | 143 | 144 | 146 | 147 | 149 |
| 0°-55' | 136 | 138 | 139 | 140 | 142 |
| 1°-00' | 130 | 132 | 133 | 134 | 136 |
| 1°-15' | 117 | 118 | 119 | 120 | 121 |
| 1°-30' | 106 | 108 | 109 | 110 | 111 |
| 1°-45' | 98 | 100 | 101 | 102 | 103 |
| 2°-00' | 92 | 93 | 94 | 95 | 96 |
| 2°-15' | 87 | 88 | 89 | 89 | 90 |
| 2°-30' | 82 | 83 | 84 | 85 | 86 |
| 2°-45' | 78 | 79 | 80 | 81 | 82 |
| 3°-00' | 75 | 76 | 77 | 77 | 78 |
| 3°-15' | 72 | 73 | 74 | 74 | 75 |
| 3°-30' | 69 | 70 | 71 | 72 | 72 |
| 3°-45' | 67 | 68 | 69 | 69 | 70 |
| 4°-00' | 65 | 66 | 66 | 67 | 68 |
| 4°-15' | 63 | 64 | 64 | 65 | 66 |
| 4°-30' | 61 | 62 | 62 | 63 | 64 |
| 4°-45' | 60 | 60 | 61 | 61 | 62 |
| 5°-00' | 58 | 59 | 59 | 60 | 60 |
| 5°-30' | 55 | 56 | 56 | 57 | 58 |
| 6°-00' | 53 | 54 | 54 | 55 | 55 |
| 6°-30' | 51 | 51 | 52 | 52 | 53 |
| 7°-00' | 49 | 50 | 50 | 51 | 51 |
| 7°-30' | 47 | 48 | 48 | 49 | 49 |
| 8°-00' | 46 | 46 | 47 | 47 | 48 |
| 8°-30' | 44 | 45 | 45 | 46 | 46 |
| 9°-00' | 43 | 44 | 44 | 44 | 45 |
| 9°-30' | 42 | 42 | 43 | 43 | 44 |
| 10°-00' | 41 | 41 | 42 | 42 | 43 |
| 10°-30' | 40 | 40 | 41 | 41 | 42 |
| 11°-00' | 39 | 39 | 40 | 40 | 41 |
| 11°-30' | 38 | 39 | 39 | 39 | 40 |
| 12°-00' | 37 | 38 | 38 | 38 | 39 |
| 12°-30' | 37 | 37 | 37 | 38 | 38 |
| 13°-00' | 36 | 36 | 37 | 37 | 37 |
| 13°-30' | 35 | 36 | 36 | 36 | 37 |
| 14°-00' | 34 | 35 | 35 | 36 | 36 |
| 14°-30' | 34 | 34 | 35 | 35 | 35 |
| 15°-00' | 33 | 34 | 34 | 34 | 35 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 8" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0-0** | **0-1/4** | **0-1/2** | **0-3/4** | **1** | **1-1/4** | **1-1/2** | **1-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 185 | 188 | 190 | 193 | 196 | 199 | 200 | 200 |
| 0°-25' | 165 | 168 | 170 | 173 | 175 | 178 | 180 | 182 |
| 0°-30' | 151 | 153 | 155 | 158 | 160 | 162 | 164 | 166 |
| 0°-35' | 139 | 142 | 144 | 146 | 148 | 150 | 152 | 154 |
| 0°-40' | 130 | 132 | 134 | 136 | 138 | 140 | 142 | 144 |
| 0°-45' | 123 | 125 | 127 | 129 | 130 | 132 | 134 | 136 |
| 0°-50' | 117 | 118 | 120 | 122 | 124 | 125 | 127 | 129 |
| 0°-55' | 111 | 113 | 115 | 116 | 118 | 120 | 121 | 123 |
| 1°-00' | 106 | 108 | 110 | 111 | 113 | 114 | 116 | 118 |
| 1°-15' | 95 | 97 | 98 | 100 | 101 | 102 | 104 | 105 |
| 1°-30' | 87 | 88 | 89 | 91 | 92 | 93 | 95 | 96 |
| 1°-45' | 80 | 82 | 83 | 84 | 85 | 86 | 88 | 89 |
| 2°-00' | 75 | 76 | 77 | 79 | 80 | 81 | 82 | 83 |
| 2°-15' | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 |
| 2°-30' | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 |
| 2°-45' | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| 3°-00' | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 |
| 3°-15' | 59 | 60 | 61 | 62 | 62 | 63 | 64 | 65 |
| 3°-30' | 57 | 58 | 58 | 59 | 60 | 61 | 62 | 63 |
| 3°-45' | 55 | 56 | 56 | 57 | 58 | 59 | 60 | 60 |
| 4°-00' | 53 | 54 | 55 | 55 | 56 | 57 | 58 | 59 |
| 4°-15' | 51 | 52 | 53 | 54 | 55 | 55 | 56 | 57 |
| 4°-30' | 50 | 51 | 51 | 52 | 53 | 54 | 54 | 55 |
| 4°-45' | 49 | 49 | 50 | 51 | 52 | 52 | 53 | 54 |
| 5°-00' | 47 | 48 | 49 | 50 | 50 | 51 | 52 | 52 |
| 5°-30' | 45 | 46 | 46 | 47 | 48 | 49 | 49 | 50 |
| 6°-00' | 43 | 44 | 44 | 45 | 46 | 46 | 47 | 48 |
| 6°-30' | 41 | 42 | 43 | 43 | 44 | 45 | 45 | 46 |
| 7°-00' | 40 | 41 | 41 | 42 | 42 | 43 | 44 | 44 |
| 7°-30' | 39 | 39 | 40 | 40 | 41 | 41 | 42 | 43 |
| 8°-00' | 37 | 38 | 38 | 39 | 40 | 40 | 41 | 41 |
| 8°-30' | 36 | 37 | 37 | 38 | 38 | 39 | 39 | 40 |
| 9°-00' | 35 | 36 | 36 | 37 | 37 | 38 | 38 | 39 |
| 9°-30' | 34 | 35 | 35 | 36 | 36 | 37 | 37 | 38 |
| 10°-00' | 33 | 34 | 34 | 35 | 35 | 36 | 36 | 37 |
| 10°-30' | 32 | 33 | 34 | 34 | 34 | 35 | 35 | 36 |
| 11°-00' | 32 | 32 | 33 | 33 | 34 | 34 | 35 | 35 |
| 11°-30' | 31 | 32 | 32 | 32 | 33 | 33 | 34 | 34 |
| 12°-00' | 30 | 31 | 31 | 32 | 32 | 33 | 33 | 34 |
| 12°-30' | 30 | 30 | 31 | 31 | 32 | 32 | 32 | 33 |
| 13°-00' | 29 | 30 | 30 | 31 | 31 | 31 | 32 | 32 |
| 13°-30' | 29 | 29 | 29 | 30 | 30 | 31 | 31 | 32 |
| 14°-00' | 28 | 29 | 29 | 29 | 30 | 30 | 31 | 31 |
| 14°-30' | 28 | 28 | 28 | 29 | 29 | 30 | 30 | 30 |
| 15°-00' | 27 | 28 | 28 | 28 | 29 | 29 | 30 | 30 |

Note: All curves under 0º-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves

**Underbalance = 8" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | **2** | **2-1/4** | **2-1/2** | **2-3/4** | **3** | **3-1/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 185 | 187 | 189 | 191 | 194 | 196 |
| 0°-30' | 169 | 171 | 173 | 175 | 177 | 179 |
| 0°-35' | 156 | 158 | 160 | 162 | 164 | 165 |
| 0°-40' | 146 | 148 | 149 | 151 | 153 | 155 |
| 0°-45' | 138 | 139 | 141 | 143 | 144 | 146 |
| 0°-50' | 130 | 132 | 134 | 135 | 137 | 138 |
| 0°-55' | 124 | 126 | 127 | 129 | 130 | 132 |
| 1°-00' | 119 | 121 | 122 | 123 | 125 | 126 |
| 1°-15' | 106 | 108 | 109 | 110 | 112 | 113 |
| 1°-30' | 97 | 98 | 100 | 101 | 102 | 103 |
| 1°-45' | 90 | 91 | 92 | 93 | 94 | 95 |
| 2°-00' | 84 | 85 | 86 | 87 | 88 | 89 |
| 2°-15' | 79 | 80 | 81 | 82 | 83 | 84 |
| 2°-30' | 75 | 76 | 77 | 78 | 79 | 80 |
| 2°-45' | 72 | 72 | 73 | 74 | 75 | 76 |
| 3°-00' | 69 | 69 | 70 | 71 | 72 | 73 |
| 3°-15' | 66 | 67 | 67 | 68 | 69 | 70 |
| 3°-30' | 63 | 64 | 65 | 66 | 67 | 67 |
| 3°-45' | 61 | 62 | 63 | 63 | 64 | 65 |
| 4°-00' | 59 | 60 | 61 | 61 | 62 | 63 |
| 4°-15' | 57 | 58 | 59 | 60 | 60 | 61 |
| 4°-30' | 56 | 57 | 57 | 58 | 59 | 59 |
| 4°-45' | 54 | 55 | 56 | 56 | 57 | 58 |
| 5°-00' | 53 | 54 | 54 | 55 | 56 | 56 |
| 5°-30' | 50 | 51 | 52 | 52 | 53 | 54 |
| 6°-00' | 48 | 49 | 50 | 50 | 51 | 51 |
| 6°-30' | 46 | 47 | 48 | 48 | 49 | 49 |
| 7°-00' | 45 | 45 | 46 | 46 | 47 | 47 |
| 7°-30' | 43 | 44 | 44 | 45 | 45 | 46 |
| 8°-00' | 42 | 42 | 43 | 43 | 44 | 44 |
| 8°-30' | 40 | 41 | 42 | 42 | 42 | 43 |
| 9°-00' | 39 | 40 | 40 | 41 | 41 | 42 |
| 9°-30' | 38 | 39 | 39 | 40 | 40 | 41 |
| 10°-00' | 37 | 38 | 38 | 39 | 39 | 40 |
| 10°-30' | 36 | 37 | 37 | 38 | 38 | 39 |
| 11°-00' | 36 | 36 | 36 | 37 | 37 | 38 |
| 11°-30' | 35 | 35 | 36 | 36 | 36 | 37 |
| 12°-00' | 34 | 34 | 35 | 35 | 36 | 36 |
| 12°-30' | 33 | 34 | 34 | 35 | 35 | 35 |
| 13°-00' | 33 | 33 | 33 | 34 | 34 | 35 |
| 13°-30' | 32 | 32 | 33 | 33 | 34 | 34 |
| 14°-00' | 31 | 32 | 32 | 33 | 33 | 33 |
| 14°-30' | 31 | 31 | 32 | 32 | 32 | 33 |
| 15°-00' | 30 | 31 | 31 | 31 | 32 | 32 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 8" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | **3-1/2** | **3-3/4** | **4** | **4-1/4** | **4-1/2** | **4-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 198 | 200 | 200 | 200 | 200 | 200 |
| 0°-30' | 181 | 183 | 185 | 187 | 188 | 190 |
| 0°-35' | 167 | 169 | 171 | 173 | 174 | 176 |
| 0°-40' | 156 | 158 | 160 | 162 | 163 | 165 |
| 0°-45' | 148 | 149 | 151 | 152 | 154 | 155 |
| 0°-50' | 140 | 141 | 143 | 144 | 146 | 147 |
| 0°-55' | 133 | 135 | 136 | 138 | 139 | 140 |
| 1°-00' | 128 | 129 | 130 | 132 | 133 | 134 |
| 1°-15' | 114 | 115 | 117 | 118 | 119 | 120 |
| 1°-30' | 104 | 105 | 106 | 108 | 109 | 110 |
| 1°-45' | 96 | 97 | 98 | 100 | 101 | 102 |
| 2°-00' | 90 | 91 | 92 | 93 | 94 | 95 |
| 2°-15' | 85 | 86 | 87 | 88 | 89 | 89 |
| 2°-30' | 81 | 81 | 82 | 83 | 84 | 85 |
| 2°-45' | 77 | 78 | 78 | 79 | 80 | 81 |
| 3°-00' | 74 | 74 | 75 | 76 | 77 | 77 |
| 3°-15' | 71 | 71 | 72 | 73 | 74 | 74 |
| 3°-30' | 68 | 69 | 69 | 70 | 71 | 72 |
| 3°-45' | 66 | 66 | 67 | 68 | 69 | 69 |
| 4°-00' | 64 | 64 | 65 | 66 | 66 | 67 |
| 4°-15' | 62 | 62 | 63 | 64 | 64 | 65 |
| 4°-30' | 60 | 61 | 61 | 62 | 62 | 63 |
| 4°-45' | 58 | 59 | 60 | 60 | 61 | 61 |
| 5°-00' | 57 | 57 | 58 | 59 | 59 | 60 |
| 5°-30' | 54 | 55 | 55 | 56 | 56 | 57 |
| 6°-00' | 52 | 52 | 53 | 54 | 54 | 55 |
| 6°-30' | 50 | 50 | 51 | 51 | 52 | 52 |
| 7°-00' | 48 | 48 | 49 | 50 | 50 | 51 |
| 7°-30' | 46 | 47 | 47 | 48 | 48 | 49 |
| 8°-00' | 45 | 45 | 46 | 46 | 47 | 47 |
| 8°-30' | 43 | 44 | 44 | 45 | 45 | 46 |
| 9°-00' | 42 | 43 | 43 | 44 | 44 | 44 |
| 9°-30' | 41 | 42 | 42 | 42 | 43 | 43 |
| 10°-00' | 40 | 40 | 41 | 41 | 42 | 42 |
| 10°-30' | 39 | 39 | 40 | 40 | 41 | 41 |
| 11°-00' | 38 | 39 | 39 | 39 | 40 | 40 |
| 11°-30' | 37 | 38 | 38 | 39 | 39 | 39 |
| 12°-00' | 37 | 37 | 37 | 38 | 38 | 38 |
| 12°-30' | 36 | 36 | 37 | 37 | 37 | 38 |
| 13°-00' | 35 | 35 | 36 | 36 | 37 | 37 |
| 13°-30' | 34 | 35 | 35 | 36 | 36 | 36 |
| 14°-00' | 34 | 34 | 34 | 35 | 35 | 36 |
| 14°-30' | 33 | 34 | 34 | 34 | 35 | 35 |
| 15°-00' | 33 | 33 | 33 | 34 | 34 | 34 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves

**Underbalance = 8" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | |
|---|---|---|---|---|---|
| | **5** | **5-1/4** | **5-1/2** | **5-3/4** | **6** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 200 | 200 | 200 | 200 | 200 |
| 0°-30' | 192 | 194 | 196 | 198 | 200 |
| 0°-35' | 178 | 180 | 181 | 183 | 185 |
| 0°-40' | 166 | 168 | 170 | 171 | 173 |
| 0°-45' | 157 | 158 | 160 | 161 | 163 |
| 0°-50' | 149 | 150 | 152 | 153 | 154 |
| 0°-55' | 142 | 143 | 145 | 146 | 147 |
| 1°-00' | 136 | 137 | 138 | 140 | 141 |
| 1°-15' | 121 | 123 | 124 | 125 | 126 |
| 1°-30' | 111 | 112 | 113 | 114 | 115 |
| 1°-45' | 103 | 104 | 104 | 105 | 106 |
| 2°-00' | 96 | 97 | 98 | 99 | 100 |
| 2°-15' | 90 | 91 | 92 | 93 | 94 |
| 2°-30' | 86 | 87 | 87 | 88 | 89 |
| 2°-45' | 82 | 82 | 83 | 84 | 85 |
| 3°-00' | 78 | 79 | 80 | 80 | 81 |
| 3°-15' | 75 | 76 | 77 | 77 | 78 |
| 3°-30' | 72 | 73 | 74 | 74 | 75 |
| 3°-45' | 70 | 71 | 71 | 72 | 73 |
| 4°-00' | 68 | 68 | 69 | 70 | 70 |
| 4°-15' | 66 | 66 | 67 | 67 | 68 |
| 4°-30' | 64 | 64 | 65 | 66 | 66 |
| 4°-45' | 62 | 63 | 63 | 64 | 64 |
| 5°-00' | 60 | 61 | 62 | 62 | 63 |
| 5°-30' | 58 | 58 | 59 | 59 | 60 |
| 6°-00' | 55 | 56 | 56 | 57 | 57 |
| 6°-30' | 53 | 53 | 54 | 54 | 55 |
| 7°-00' | 51 | 52 | 52 | 52 | 53 |
| 7°-30' | 49 | 50 | 50 | 51 | 51 |
| 8°-00' | 48 | 48 | 49 | 49 | 50 |
| 8°-30' | 46 | 47 | 47 | 48 | 48 |
| 9°-00' | 45 | 45 | 46 | 46 | 47 |
| 9°-30' | 44 | 44 | 45 | 45 | 45 |
| 10°-00' | 43 | 43 | 43 | 44 | 44 |
| 10°-30' | 42 | 42 | 42 | 43 | 43 |
| 11°-00' | 41 | 41 | 41 | 42 | 42 |
| 11°-30' | 40 | 40 | 40 | 41 | 41 |
| 12°-00' | 39 | 39 | 40 | 40 | 40 |
| 12°-30' | 38 | 38 | 39 | 39 | 40 |
| 13°-00' | 37 | 38 | 38 | 38 | 39 |
| 13°-30' | 37 | 37 | 37 | 38 | 38 |
| 14°-00' | 36 | 36 | 37 | 37 | 37 |
| 14°-30' | 35 | 36 | 36 | 36 | 37 |
| 15°-00' | 35 | 35 | 35 | 36 | 36 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 9" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0-0** | **0-1/4** | **0-1/2** | **0-3/4** | **1** | **1-1/4** | **1-1/2** | **1-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 196 | 199 | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 175 | 178 | 180 | 182 | 185 | 187 | 189 | 191 |
| 0°-30' | 160 | 162 | 164 | 166 | 169 | 171 | 173 | 175 |
| 0°-35' | 148 | 150 | 152 | 154 | 156 | 158 | 160 | 162 |
| 0°-40' | 138 | 140 | 142 | 144 | 146 | 148 | 149 | 151 |
| 0°-45' | 130 | 132 | 134 | 136 | 138 | 139 | 141 | 143 |
| 0°-50' | 124 | 125 | 127 | 129 | 130 | 132 | 134 | 135 |
| 0°-55' | 118 | 120 | 121 | 123 | 124 | 126 | 127 | 129 |
| 1°-00' | 113 | 114 | 116 | 118 | 119 | 121 | 122 | 123 |
| 1°-15' | 101 | 102 | 104 | 105 | 106 | 108 | 109 | 110 |
| 1°-30' | 92 | 93 | 95 | 96 | 97 | 98 | 100 | 101 |
| 1°-45' | 85 | 86 | 88 | 89 | 90 | 91 | 92 | 93 |
| 2°-00' | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 |
| 2°-15' | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 |
| 2°-30' | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 |
| 2°-45' | 68 | 69 | 70 | 71 | 72 | 72 | 73 | 74 |
| 3°-00' | 65 | 66 | 67 | 68 | 69 | 69 | 70 | 71 |
| 3°-15' | 62 | 63 | 64 | 65 | 66 | 67 | 67 | 68 |
| 3°-30' | 60 | 61 | 62 | 63 | 63 | 64 | 65 | 66 |
| 3°-45' | 58 | 59 | 60 | 60 | 61 | 62 | 63 | 63 |
| 4°-00' | 56 | 57 | 58 | 59 | 59 | 60 | 61 | 61 |
| 4°-15' | 55 | 55 | 56 | 57 | 57 | 58 | 59 | 60 |
| 4°-30' | 53 | 54 | 54 | 55 | 56 | 57 | 57 | 58 |
| 4°-45' | 52 | 52 | 53 | 54 | 54 | 55 | 56 | 56 |
| 5°-00' | 50 | 51 | 52 | 52 | 53 | 54 | 54 | 55 |
| 5°-30' | 48 | 49 | 49 | 50 | 50 | 51 | 52 | 52 |
| 6°-00' | 46 | 46 | 47 | 48 | 48 | 49 | 50 | 50 |
| 6°-30' | 44 | 45 | 45 | 46 | 46 | 47 | 48 | 48 |
| 7°-00' | 42 | 43 | 44 | 44 | 45 | 45 | 46 | 46 |
| 7°-30' | 41 | 41 | 42 | 43 | 43 | 44 | 44 | 45 |
| 8°-00' | 40 | 40 | 41 | 41 | 42 | 42 | 43 | 43 |
| 8°-30' | 38 | 39 | 39 | 40 | 40 | 41 | 42 | 42 |
| 9°-00' | 37 | 38 | 38 | 39 | 39 | 40 | 40 | 41 |
| 9°-30' | 36 | 37 | 37 | 38 | 38 | 39 | 39 | 40 |
| 10°-00' | 35 | 36 | 36 | 37 | 37 | 38 | 38 | 39 |
| 10°-30' | 34 | 35 | 35 | 36 | 36 | 37 | 37 | 38 |
| 11°-00' | 34 | 34 | 35 | 35 | 36 | 36 | 36 | 37 |
| 11°-30' | 33 | 33 | 34 | 34 | 35 | 35 | 36 | 36 |
| 12°-00' | 32 | 33 | 33 | 34 | 34 | 34 | 35 | 35 |
| 12°-30' | 32 | 32 | 32 | 33 | 33 | 34 | 34 | 35 |
| 13°-00' | 31 | 31 | 32 | 32 | 33 | 33 | 33 | 34 |
| 13°-30' | 30 | 31 | 31 | 32 | 32 | 32 | 33 | 33 |
| 14°-00' | 30 | 30 | 31 | 31 | 31 | 32 | 32 | 33 |
| 14°-30' | 29 | 30 | 30 | 30 | 31 | 31 | 32 | 32 |
| 15°-00' | 29 | 29 | 30 | 30 | 30 | 31 | 31 | 31 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 9" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | **2** | **2-1/4** | **2-1/2** | **2-3/4** | **3** | **3-1/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 194 | 196 | 198 | 200 | 200 | 200 |
| 0°-30' | 177 | 179 | 181 | 183 | 185 | 187 |
| 0°-35' | 164 | 165 | 167 | 169 | 171 | 173 |
| 0°-40' | 153 | 155 | 156 | 158 | 160 | 162 |
| 0°-45' | 144 | 146 | 148 | 149 | 151 | 152 |
| 0°-50' | 137 | 138 | 140 | 141 | 143 | 144 |
| 0°-55' | 130 | 132 | 133 | 135 | 136 | 138 |
| 1°-00' | 125 | 126 | 128 | 129 | 130 | 132 |
| 1°-15' | 112 | 113 | 114 | 115 | 117 | 118 |
| 1°-30' | 102 | 103 | 104 | 105 | 106 | 108 |
| 1°-45' | 94 | 95 | 96 | 97 | 98 | 100 |
| 2°-00' | 88 | 89 | 90 | 91 | 92 | 93 |
| 2°-15' | 83 | 84 | 85 | 86 | 87 | 88 |
| 2°-30' | 79 | 80 | 81 | 81 | 82 | 83 |
| 2°-45' | 75 | 76 | 77 | 78 | 78 | 79 |
| 3°-00' | 72 | 73 | 74 | 74 | 75 | 76 |
| 3°-15' | 69 | 70 | 71 | 71 | 72 | 73 |
| 3°-30' | 67 | 67 | 68 | 69 | 69 | 70 |
| 3°-45' | 64 | 65 | 66 | 66 | 67 | 68 |
| 4°-00' | 62 | 63 | 64 | 64 | 65 | 66 |
| 4°-15' | 60 | 61 | 62 | 62 | 63 | 64 |
| 4°-30' | 59 | 59 | 60 | 61 | 61 | 62 |
| 4°-45' | 57 | 58 | 58 | 59 | 60 | 60 |
| 5°-00' | 56 | 56 | 57 | 57 | 58 | 59 |
| 5°-30' | 53 | 54 | 54 | 55 | 55 | 56 |
| 6°-00' | 51 | 51 | 52 | 52 | 53 | 54 |
| 6°-30' | 49 | 49 | 50 | 50 | 51 | 51 |
| 7°-00' | 47 | 47 | 48 | 48 | 49 | 50 |
| 7°-30' | 45 | 46 | 46 | 47 | 47 | 48 |
| 8°-00' | 44 | 44 | 45 | 45 | 46 | 46 |
| 8°-30' | 42 | 43 | 43 | 44 | 44 | 45 |
| 9°-00' | 41 | 42 | 42 | 43 | 43 | 44 |
| 9°-30' | 40 | 41 | 41 | 42 | 42 | 42 |
| 10°-00' | 39 | 40 | 40 | 40 | 41 | 41 |
| 10°-30' | 38 | 39 | 39 | 39 | 40 | 40 |
| 11°-00' | 37 | 38 | 38 | 39 | 39 | 39 |
| 11°-30' | 36 | 37 | 37 | 38 | 38 | 39 |
| 12°-00' | 36 | 36 | 37 | 37 | 37 | 38 |
| 12°-30' | 35 | 35 | 36 | 36 | 37 | 37 |
| 13°-00' | 34 | 35 | 35 | 35 | 36 | 36 |
| 13°-30' | 34 | 34 | 34 | 35 | 35 | 36 |
| 14°-00' | 33 | 33 | 34 | 34 | 34 | 35 |
| 14°-30' | 32 | 33 | 33 | 34 | 34 | 34 |
| 15°-00' | 32 | 32 | 33 | 33 | 33 | 34 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 9" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | | |
|---|---|---|---|---|---|---|
| | **3-1/2** | **3-3/4** | **4** | **4-1/4** | **4-1/2** | **4-3/4** |
| **Curvature (D)** | **Speed in Miles Per Hour (Vmax)** | | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 200 | 200 | 200 | 200 | 200 | 200 |
| 0°-30' | 188 | 190 | 192 | 194 | 196 | 198 |
| 0°-35' | 174 | 176 | 178 | 180 | 181 | 183 |
| 0°-40' | 163 | 165 | 166 | 168 | 170 | 171 |
| 0°-45' | 154 | 155 | 157 | 158 | 160 | 161 |
| 0°-50' | 146 | 147 | 149 | 150 | 152 | 153 |
| 0°-55' | 139 | 140 | 142 | 143 | 145 | 146 |
| 1°-00' | 133 | 134 | 136 | 137 | 138 | 140 |
| 1°-15' | 119 | 120 | 121 | 123 | 124 | 125 |
| 1°-30' | 109 | 110 | 111 | 112 | 113 | 114 |
| 1°-45' | 101 | 102 | 103 | 104 | 104 | 105 |
| 2°-00' | 94 | 95 | 96 | 97 | 98 | 99 |
| 2°-15' | 89 | 89 | 90 | 91 | 92 | 93 |
| 2°-30' | 84 | 85 | 86 | 87 | 87 | 88 |
| 2°-45' | 80 | 81 | 82 | 82 | 83 | 84 |
| 3°-00' | 77 | 77 | 78 | 79 | 80 | 80 |
| 3°-15' | 74 | 74 | 75 | 76 | 77 | 77 |
| 3°-30' | 71 | 72 | 72 | 73 | 74 | 74 |
| 3°-45' | 69 | 69 | 70 | 71 | 71 | 72 |
| 4°-00' | 66 | 67 | 68 | 68 | 69 | 70 |
| 4°-15' | 64 | 65 | 66 | 66 | 67 | 67 |
| 4°-30' | 62 | 63 | 64 | 64 | 65 | 66 |
| 4°-45' | 61 | 61 | 62 | 63 | 63 | 64 |
| 5°-00' | 59 | 60 | 60 | 61 | 62 | 62 |
| 5°-30' | 56 | 57 | 58 | 58 | 59 | 59 |
| 6°-00' | 54 | 55 | 55 | 56 | 56 | 57 |
| 6°-30' | 52 | 52 | 53 | 53 | 54 | 54 |
| 7°-00' | 50 | 51 | 51 | 52 | 52 | 52 |
| 7°-30' | 48 | 49 | 49 | 50 | 50 | 51 |
| 8°-00' | 47 | 47 | 48 | 48 | 49 | 49 |
| 8°-30' | 45 | 46 | 46 | 47 | 47 | 48 |
| 9°-00' | 44 | 44 | 45 | 45 | 46 | 46 |
| 9°-30' | 43 | 43 | 44 | 44 | 45 | 45 |
| 10°-00' | 42 | 42 | 43 | 43 | 43 | 44 |
| 10°-30' | 41 | 41 | 42 | 42 | 42 | 43 |
| 11°-00' | 40 | 40 | 41 | 41 | 41 | 42 |
| 11°-30' | 39 | 39 | 40 | 40 | 40 | 41 |
| 12°-00' | 38 | 38 | 39 | 39 | 40 | 40 |
| 12°-30' | 37 | 38 | 38 | 38 | 39 | 39 |
| 13°-00' | 37 | 37 | 37 | 38 | 38 | 38 |
| 13°-30' | 36 | 36 | 37 | 37 | 37 | 38 |
| 14°-00' | 35 | 36 | 36 | 36 | 37 | 37 |
| 14°-30' | 35 | 35 | 35 | 36 | 36 | 36 |
| 15°-00' | 34 | 34 | 35 | 35 | 35 | 36 |

Note: All curves under 0°-20' will have a minimum of 1/2" superelevation

Maximum Allowable Operating Speed on Curves
**Underbalance = 9" ($E_u$)**

| | Superelevation in Inches (Ea) | | | | |
|---|---|---|---|---|---|
| | 5 | 5-1/4 | 5-1/2 | 5-3/4 | 6 |
| Curvature (D) | Speed in Miles Per Hour (Vmax) | | | | |
| 0°-05' | 200 | 200 | 200 | 200 | 200 |
| 0°-10' | 200 | 200 | 200 | 200 | 200 |
| 0°-15' | 200 | 200 | 200 | 200 | 200 |
| 0°-20' | 200 | 200 | 200 | 200 | 200 |
| 0°-25' | 200 | 200 | 200 | 200 | 200 |
| 0°-30' | 200 | 200 | 200 | 200 | 200 |
| 0°-35' | 185 | 186 | 188 | 190 | 191 |
| 0°-40' | 173 | 174 | 176 | 177 | 179 |
| 0°-45' | 163 | 164 | 166 | 167 | 169 |
| 0°-50' | 154 | 156 | 157 | 159 | 160 |
| 0°-55' | 147 | 149 | 150 | 151 | 152 |
| 1°-00' | 141 | 142 | 143 | 145 | 146 |
| 1°-15' | 126 | 127 | 128 | 129 | 130 |
| 1°-30' | 115 | 116 | 117 | 118 | 119 |
| 1°-45' | 106 | 107 | 108 | 109 | 110 |
| 2°-00' | 100 | 100 | 101 | 102 | 103 |
| 2°-15' | 94 | 95 | 95 | 96 | 97 |
| 2°-30' | 89 | 90 | 91 | 91 | 92 |
| 2°-45' | 85 | 86 | 86 | 87 | 88 |
| 3°-00' | 81 | 82 | 83 | 83 | 84 |
| 3°-15' | 78 | 79 | 79 | 80 | 81 |
| 3°-30' | 75 | 76 | 76 | 77 | 78 |
| 3°-45' | 73 | 73 | 74 | 74 | 75 |
| 4°-00' | 70 | 71 | 71 | 72 | 73 |
| 4°-15' | 68 | 69 | 69 | 70 | 71 |
| 4°-30' | 66 | 67 | 67 | 68 | 69 |
| 4°-45' | 64 | 65 | 66 | 66 | 67 |
| 5°-00' | 63 | 63 | 64 | 64 | 65 |
| 5°-30' | 60 | 60 | 61 | 61 | 62 |
| 6°-00' | 57 | 58 | 58 | 59 | 59 |
| 6°-30' | 55 | 55 | 56 | 56 | 57 |
| 7°-00' | 53 | 53 | 54 | 54 | 55 |
| 7°-30' | 51 | 52 | 52 | 53 | 53 |
| 8°-00' | 50 | 50 | 50 | 51 | 51 |
| 8°-30' | 48 | 48 | 49 | 49 | 50 |
| 9°-00' | 47 | 47 | 47 | 48 | 48 |
| 9°-30' | 45 | 46 | 46 | 47 | 47 |
| 10°-00' | 44 | 45 | 45 | 45 | 46 |
| 10°-30' | 43 | 44 | 44 | 44 | 45 |
| 11°-00' | 42 | 43 | 43 | 43 | 44 |
| 11°-30' | 41 | 42 | 42 | 42 | 43 |
| 12°-00' | 40 | 41 | 41 | 41 | 42 |
| 12°-30' | 40 | 40 | 40 | 41 | 41 |
| 13°-00' | 39 | 39 | 39 | 40 | 40 |
| 13°-30' | 38 | 38 | 39 | 39 | 39 |
| 14°-00' | 37 | 38 | 38 | 38 | 39 |
| 14°-30' | 37 | 37 | 37 | 38 | 38 |
| 15°-00' | 36 | 36 | 37 | 37 | 37 |

Note: All curves under 0º-20' will have a minimum of 1/2" superelevation

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## APPENDIX C BRAKING DISTANCE TABLE

Distance From Approach Speed Signs To Speed Limit Signs and Stop Signs

| Speed Reduction (MPH) | | Distance between signs (feet) (Level or ascending grades) | |
|---|---|---|---|
| From | To | Passenger | Freight |
| 150 | 140 | 3,400 | |
| 150 | 130 | 5,000 | |
| 150 | 120 | 6,400 | |
| 150 | 110 | 7,700 | |
| 150 | 100 | 8,900 | |
| 150 | 90 | 9,900 | |
| 150 | 80 | 10,900 | |
| 150 | 70 | 11,800 | |
| 150 | 60 | 12,500 | |
| 150 | 50 | 13,100 | |
| 150 | 40 | 13,600 | |
| 150 | 30 | 14,000 | |
| 150 | 20 | 14,300 | |
| 150 | 10 | 14,400 | |
| 150 | 0 | 14,500 | |
| 140 | 130 | 3,200 | |
| 140 | 120 | 4,600 | |
| 140 | 110 | 5,400 | |
| 140 | 100 | 7,100 | |
| 140 | 90 | 8,200 | |
| 140 | 80 | 9,200 | |
| 140 | 70 | 10,000 | |
| 140 | 60 | 10,700 | |
| 140 | 50 | 11,400 | |
| 140 | 40 | 11,900 | |
| 140 | 30 | 12,300 | |
| 140 | 20 | 12,500 | |
| 140 | 10 | 12,700 | |
| 140 | 0 | 12,800 | |
| 130 | 120 | 3,000 | |
| 130 | 110 | 4,300 | |
| 130 | 100 | 5,500 | |
| 130 | 90 | 6,500 | |
| 130 | 80 | 7,500 | |
| 130 | 70 | 8,400 | |
| 130 | 60 | 9,100 | |
| 130 | 50 | 9,700 | |
| 130 | 40 | 10,200 | |
| 130 | 30 | 10,600 | |
| 130 | 20 | 10,900 | |
| 130 | 10 | 11,000 | |
| 130 | 0 | 11,100 | |
| 120 | 110 | 2,800 | |
| 120 | 100 | 3,900 | |
| 120 | 90 | 5,000 | |
| 120 | 80 | 6,000 | |
| 120 | 70 | 6,800 | |
| 120 | 60 | 7,600 | |

| Speed Reduction (MPH) | | Distance between signs (feet) (Level or ascending grades) | |
| --- | --- | --- | --- |
| From | To | Passenger | Freight |
| 120 | 50 | 8,200 | |
| 120 | 40 | 8,700 | |
| 120 | 30 | 9,100 | |
| 120 | 20 | 9,400 | |
| 120 | 10 | 9,500 | |
| 120 | 0 | 9,600 | |
| 110 | 100 | 2,900 | |
| 110 | 90 | 4,300 | |
| 110 | 80 | 5,600 | |
| 110 | 70 | 6,700 | |
| 110 | 60 | 7,700 | |
| 110 | 50 | 8,500 | |
| 110 | 40 | 9,200 | |
| 110 | 30 | 9,700 | |
| 110 | 20 | 10,100 | |
| 110 | 10 | 10,300 | |
| 110 | 0 | 10,400 | |
| 100 | 90 | 2,600 | |
| 100 | 80 | 3,900 | |
| 100 | 70 | 5,000 | |
| 100 | 60 | 6,000 | |
| 100 | 50 | 6,800 | |
| 100 | 40 | 7,500 | |
| 100 | 30 | 8,000 | |
| 100 | 20 | 8,400 | |
| 100 | 10 | 8,600 | |
| 100 | 0 | 8,700 | |
| 90 | 80 | 2,400 | |
| 90 | 70 | 3,500 | |
| 90 | 60 | 4,500 | |
| 90 | 50 | 5,300 | |
| 90 | 40 | 6,000 | |
| 90 | 30 | 6,500 | |
| 90 | 20 | 6,900 | |
| 90 | 10 | 7,100 | |
| 90 | 0 | 7,200 | |
| 80 | 70 | 2,100 | |
| 80 | 60 | 3,100 | |
| 80 | 50 | 3,900 | |
| 80 | 40 | 4,600 | |
| 80 | 30 | 5,100 | |
| 80 | 20 | 5,500 | |
| 80 | 10 | 5,700 | |
| 80 | 0 | 5,800 | |
| 70 | 60 | 1,800 | 3,100 |
| 70 | 50 | 2,700 | 5,800 |
| 70 | 40 | 3,300 | 8,300 |
| 70 | 30 | 3,900 | 10,500 |
| 70 | 20 | 4,200 | 12,400 |
| 70 | 10 | 4,500 | 14,000 |

| Speed Reduction (MPH) | | Distance between signs (feet) (Level or ascending grades) | |
|---|---|---|---|
| From | To | Passenger | Freight |
| 70 | 0 | 4,500 | 15,300 |
| 60 | 50 | 1,600 | 2,800 |
| 60 | 40 | 2,300 | 5,200 |
| 60 | 30 | 2,800 | 7,400 |
| 60 | 20 | 3,200 | 9,300 |
| 60 | 10 | 3,400 | 10,900 |
| 60 | 0 | 3,500 | 12,300 |
| 50 | 40 | 1,300 | 2,500 |
| 50 | 30 | 1,800 | 4,700 |
| 50 | 20 | 2,200 | 6,600 |
| 50 | 10 | 2,400 | 8,200 |
| 50 | 0 | 2,500 | 9,500 |
| 40 | 30 | 1,000 | 2,200 |
| 40 | 20 | 1,400 | 4,100 |
| 40 | 10 | 1,600 | 5,700 |
| 40 | 0 | 1,700 | 7,000 |
| 30 | 20 | 800 | 1,900 |
| 30 | 10 | 1,000 | 3,500 |
| 30 | 0 | 1,100 | 4,800 |
| 20 | 10 | 500 | 1,600 |
| 20 | 0 | 600 | 2,900 |
| 10 | 0 | 200 | 900 |

To determine the distance between Approach Speed Signs and Speed Limit or Stop Signs for descending grades, the appropriate distance from the table above should be increased as follows:

| Grades | | | | Increase |
|---|---|---|---|---|
| 0.00% | to | 0.10% | = | None |
| 0.11% | to | 0.36% | = | 10% |
| 0.37% | to | 0.66% | = | 20% |
| 0.67% | to | 0.92% | = | 30% |
| 0.93% | to | 1.14% | = | 40% |
| 1.15% | to | 1.33% | = | 50% |
| 1.34% | to | 1.50% | = | 60% |
| 1.51% | to | 1.64% | = | 70% |
| 1.65% | to | 1.78% | = | 80% |
| 1.79% | to | 1.90% | = | 90% |
| 1.91% | to | 2.00% | = | 100% |
| 2.01% | to | 2.10% | = | 110% |

Notes:

C&S Braking Distance Criteria (CE 205) used for Tier I equipment used for speeds of 110 MPH and lower.

C&S Braking Distance Criteria (S603) used for Tier II equipment for speeds greater than 110 MPH.

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**APPENDIX D RAIL DEFECT MANUAL**

*(Note: Text and photos are taken from FRA Track Inspector Rail Defect Reference Manual)*

## Table of Contents

## DEFECT NOMENCLATURE

BBJ = Broken Base Joint Area
BBO = Broken Base Outside Joint Area
BHB = Bolt Hole Break
BHJ = Bolt Hole Break Joint Area
BHO = Bolt Hole Break Outside Joint Area
BRJ = Broken Rail Joint Area
BRO = Broken Rail Outside Joint Area
CF = Compound Fissure
CH = Crushed Head
DF = Detail Fracture
DWE = Defective Weld – Electric
DWG = Defective Weld – Gas Pressure
DWP = Defective Weld Plant
DWF = Defective Weld Field
EBF = Engine Burn Fracture
HSJ = Horizontal Split Head Joint Area
HSH = Horizontal Split Head Outside Joint Area
HWJ = Head and Web Separation Joint Area
HWO = Head and Web Separation Outside Joint Area
PRJ = Piped Rail Joint Area
PRO = Piped Rail Outside Joint Area
REWF = Rail End Weld Fracture
SWJ = Split Web Joint Area
SWO = Split Web Outside Joint Area
TDC = Compound Fissure
TDD = Detail Fracture
TDE = Transverse Defect Electrode Burn
TDT = Transverse Fissure
TDW = Transverse Defect Welded Burn
TF = Transverse Fissure
TWB = Thermite Weld Boutet
TWBW = Thermite Weld Boutet Wide Gap
TWO = Thermite Weld Orgotherm
TWOW = Thermite Weld Orgotherm Wide Gap
VSJ = Vertical Split Head Joint Area
VSH = Vertical Split Head Outside Joint Area
WEBF = Welded Engine Burn Fracture

**Additional Defect Nomenclature Used by United States Railroads**

NT = No Test

SSC = Shelled, Spalled, Corrugated SD = Shell Defect

SSH = Shell Defect EB = Engine Burn REX = Rail Exception

DHS = Deep Horizontal Separation

DWG = B Defective Weld Wide Fap Boutet

DIW = Defective In-Track Weld

DSW = Defective Slot Weld

SBT = Signal Bond Thermite

FR = Flattened Rail

OTH = Damaged Rail

*NOTE: Sizing of all types of transverse-oriented defects is reported by an approximated percentage of cross-section area of the rail head. All other defect types are normally reported in inches.*

## DEVELOPMENT of DEFECTS

### Introduction

There are several factors that can influence the expected duration of rail service. The service life is affected primarily by the chemical composition of the rail, track maintenance programs, speed, and tonnage. All of these factor into the development of vertical and lateral head wear, plastic flow or deformation of the rail head, and development of rail defects.

- Track maintenance programs – Track maintenance programs consist of any track maintenance procedure that can ensure the track can maintain adequate support to reduce the amount of rail flexing, provide proper friction control, and provide rail profile maintenance that will considerably influence the rail service life.
- Wear – Lateral wear occurs primarily on the gage face when the rail is located on the high side of a curve from the presence of high-wheel flange force. Vertical wear occurs on the rail head running surface from the wheel/rail interaction during cyclical loading and rail grinding patterns.
- Plastic flow – Plastic flow or mechanical deformation of the rail head can occur on high or low rail and is normally associated in curves that carry higher axle load operations. Plastic flow is a result of wheel/rail contact stress that is exceeding the material strength of the rail steel.
- Rail defects – Rail defects develop in any type of rail, or rail welds, as a result of several conditions. These conditions normally will originate from the rail manufacturing process; cyclical loading; and impact from rolling stock, rail wear, and plastic flow.

The development of rail defects can be influenced in modern steel through an extensive maintenance program that will prolong the timeframe before the rail is subjected to the effects of excessive wear and plastic flow. This would include friction control methods and proper rail profile. However, it is impossible to accurately predict rail service life or defect development.

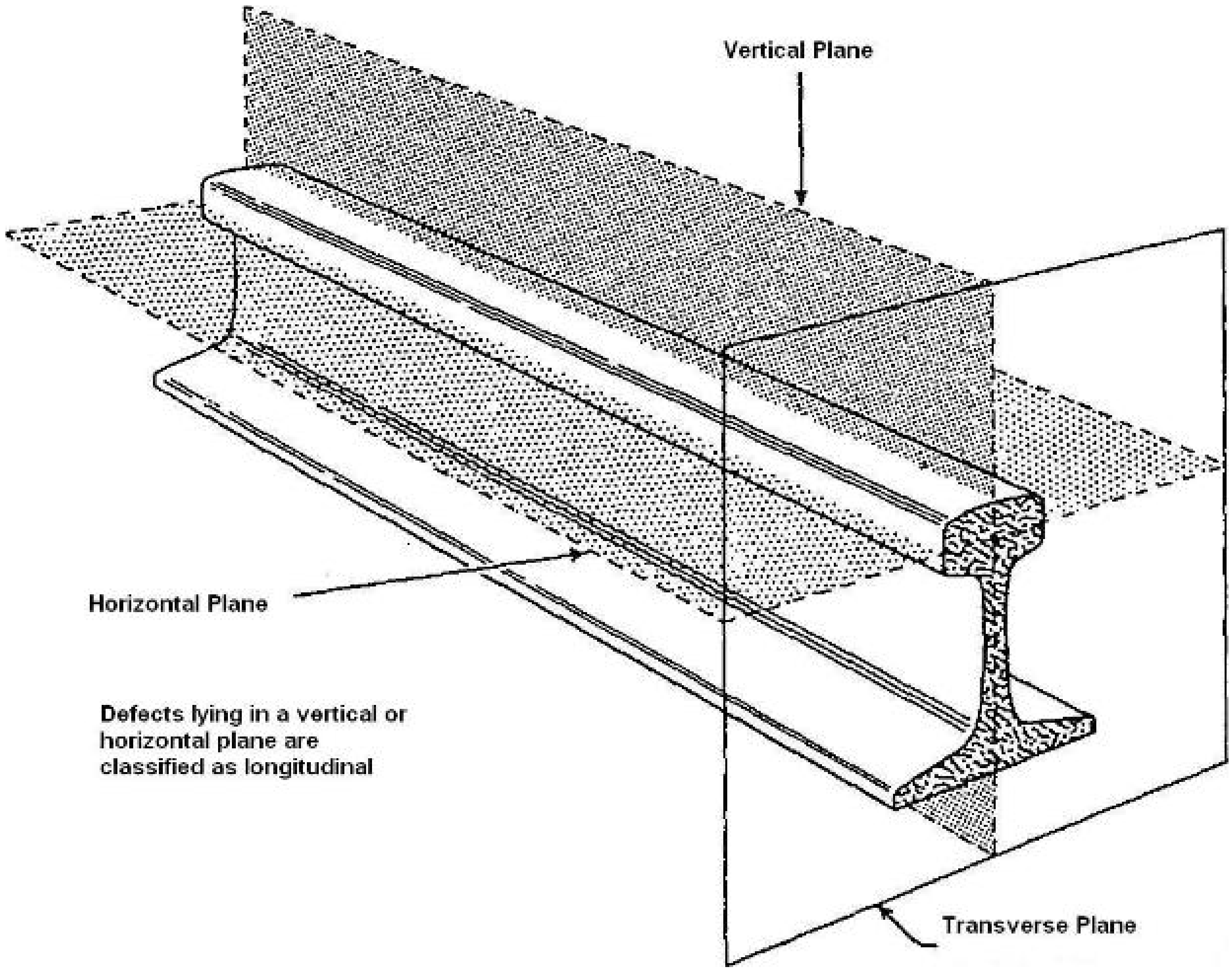


*Figure 2: Terminology Used to Identify Defect Planes in Relation to Rail Section*

**Rail Loading and Stressing**

Internal rail defects normally require certain forms of rail stresses to initiate progression and develop to a detectable size defect. Listed below is terminology that can be used to describe the planes of stresses in rail:

- Vertical Plane – stresses progressing in a longitudinal direction normal to rail length
- Horizontal Plane – stresses progressing horizontally along the rail
- Transverse Plane – stresses progressing transversely along the cross section of the rail

**Rail Loading at the Rail/Wheel Interface**

Vertical Loading – Loading forces applied by the wheel tread under normal train operation. They are normally characterized into three components referred to as static load, dynamic load, and impact load. Static load is the equivalent to the gross weight of the railcar divided by the number of wheels (i.e., 160-ton railcar with 8 wheels has a static load of 20 tons). The static loading can be influenced by track curve super-elevation. Dynamic loading is the increase of static load that results from train speed. This is a result of vertical dynamics associated with the car truck interaction with the track geometry. Impact loading is the additional increased loading over static and dynamic that occurs when a wheel travels over a significant rail head irregularity, or the wheel contains a flat spot.

*(Note: Actual vertical loading of the rail can be determined by the addition of the above components and can be considerably greater than a normal static load.)*

Lateral Loading – The load forces applied by the wheel flange to the high rail in curved track. This is a result of wheel/truck curving forces. In sharp curves, lateral loading is normally stable throughout the curve. However, in a shallow curve or tangent track, lateral loading can occur as a result of truck hunting.

Creep – Load forces that are generated at the localized rail/wheel interface by the rolling action of the wheel. Longitudinal creep forces result from traction applied to the rail head by the wheel.

Transverse creep forces result from lateral movement of the wheel during truck hunting.

**Rail Stresses**

Bending Stress – Bending of the rail that occurs from vertical wheel loading and lateral wheel loading. Vertical wheel loading normally results from loading between the tie supports and causes tensile longitudinal stresses in the rail base area and head/web fillet area. Lateral wheel loading applies tensile longitudinal stresses in the rail web area and head/web area of the rail field side.

Thermal Stress – These stresses occur in continuous welded rails due to thermal expansion and contractions that occur as the actual rail temperature increases above or reduces below the rail neutral temperature. When the rail temperature is above neutral temperature, compressive longitudinal stresses are established. When the rail temperature is below neutral temperature, tensile longitudinal stresses are established. These stresses can drastically influence rail flaw development.

Residual Stress – These stresses are a result of the manufacturing process, particularly from roller straightening and head hardening. They can also result from the welding of rails because of the different expansion and contraction of the steel that occurs during the weld process. Residual stresses can be found in any location within the rail section and can exhibit high tensile stresses that can result in rail failure.

**Defect Development Identification**

Defect development identification is determined by the type of defect, origin, and direction of development in relation to the planes of the rail section. These are identified as transverse, vertical and horizontal planes of development. The defects that develop in a transverse plane in relationship to the rail section are normally internal in origin and are not visibly identified until the defect progression penetrates the rail head.

Internal transverse defect size can only be identified visibly by breaking the cross-section of the rail in a press. After the rail is broken, a transverse defect is measured against the cross-sectional area of the rail head. If half of the rail head cross-section shows signs of defective growth, the defect is called a 50-percent fracture.

When the defective portion of the rail is closely examined, certain characteristics provide information that will allow the type of growth identification the defect had experienced. Transverse growth is normally referred to in three types of classifications:

**Normal Growth**
Defect development over a period of time in gradual stages. Normal development is typically progressive and can be uninterrupted. The defect will show a smooth and polished fracture with no granular structure. There may also be a number of identifiable smooth granular growth rings.


*Figure 3: Transverse Fissure Showing Normal Growth Pattern.*


*Figure 4: Detail Fracture Showing Normal Growth pattern*

**Rapid Growth**
Signifies recent development in numerous small stages. The small, polished, well-defined fracture is surrounded by a rough granular surface, which shows the outline of several growth rings of gradual increasing size.

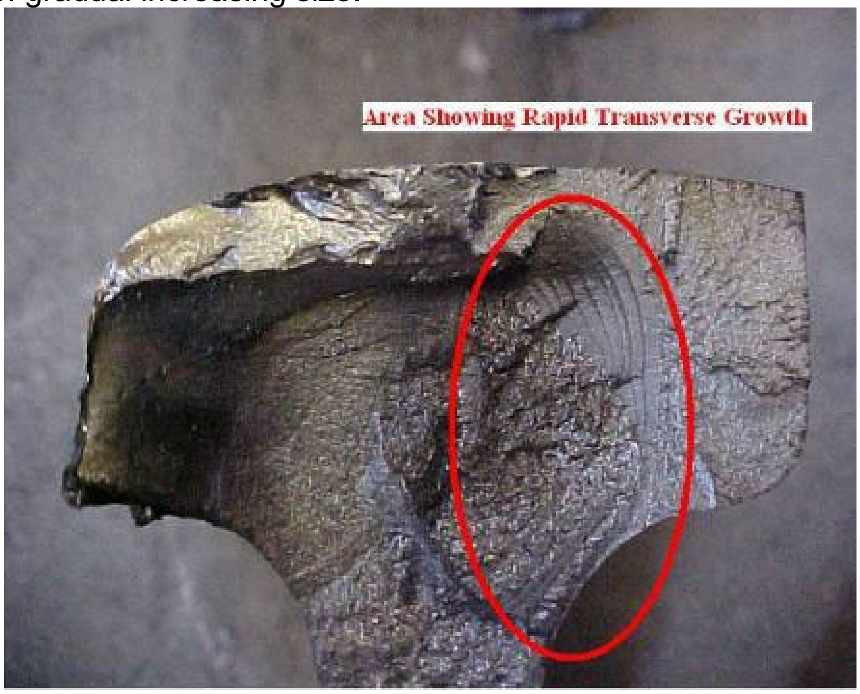


*Figure 5: Compound Fissure Showing Segments of Rapid Growth Rings.*

**Sudden Growth**
Signifies recent development in a few large stages. The small, polished, well- defined fracture is surrounded by a rough granular surface, which shows the outline of one or two growth rings. The distance between rings will increase directly with the rate of growth.


*Figure 6: Detail Fracture Showing Normal and Sudden Growth Patterns*

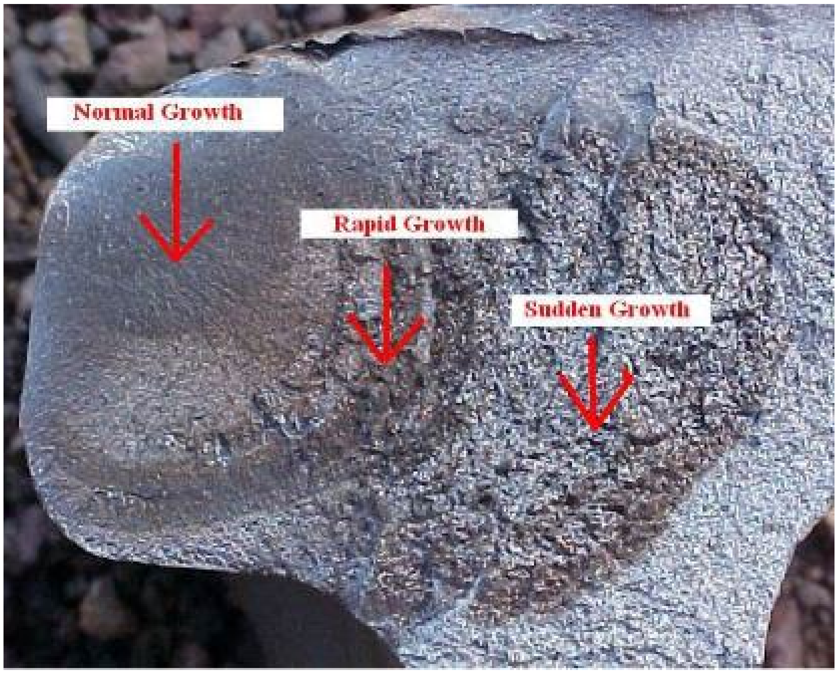

*Figure 7: Detail Fracture Showing Normal, Rapid, and Sudden Growth Patterns*

**Multiple Stage Ruptures**

Defects that develop in an oblique, angular, or longitudinal direction in relationship to the rail section can also produce identifiable stages of development, referred to as multiple stage ruptures. This is often seen in bolt hole breaks, base breaks, and head and web separations. When a longitudinal or angular defect shows signs of various stages of development each is considered a separate stage of development. This is normally identified by the presence of a preexisting identifiable fatigue condition along with another growth stage, or complete failure, referred to as secondary development. There may also be a previously oxidized portion within the break and a normal granular non-oxidized portion of break. The oxidized portion may represent the initial stage of development, and the normal granular non-oxidized portion will normally represent the secondary stage of development. It is possible to have more than two stages of development before complete failure of the defect. If a preexisting fatigue condition is not identified on the fracture face, the failure is commonly referred to as a “sudden rupture.”

*Figure 8: Vertical Split Head Showing Two-Stage Development*


*Figure 9: Weld Failure Showing 1st Stage Fatigue Development and 2nd Stage Rupture*


*Figure 10: Weld Failure Showing Preexisting Fatigue and Second Stage Rupture*

**Rail Batter**
There are two significant types of rail batter that an inspector will normally encounter during review of a rail defect. They are generally referred to as impact and friction batter. Impact batter is a result of a rail breaking exposing the fracture face to wheel impact from rolling stock. Friction batter is a result of sufficient rail section separation allowing the two fracture faces to make contact under load. Batter is identified as significant rail-end damage or a smooth polished fracture face. Both types of batter can obliterate the matching fracture faces preventing identification of an underlying fatigue condition.

*Figure 11: Impact Batter from Rolling Stock Wheels*


*Figure 12: Friction Batter from Fracture Face Contact*

# FRA RAIL DEFECTS and DESCRIPTIONS

## Transverse Defects in the Rail Head

A transverse defect is a type of fatigue that has developed in a plane transverse to the cross-sectional area of the rail head. Development can be normal or in multiple stages prior to failure. The transverse defect is only identified by the nondestructive inspection process, unless the defect has progressed to the rail running surface and has cracked out.

### Transverse Fissure

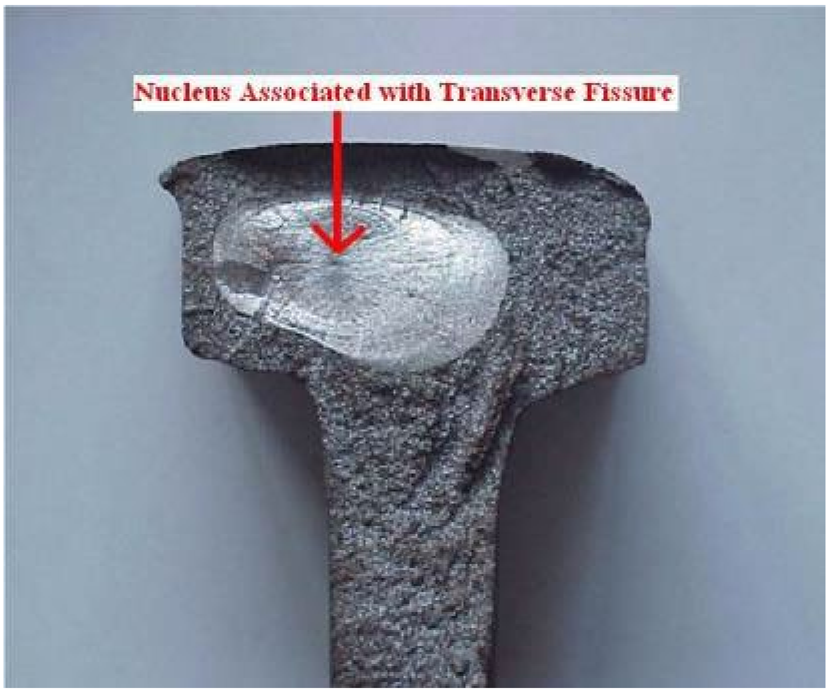


*Figure 13: Transverse Fissure*

**Description –** Transverse fissure means a progressive crosswise fracture starting from a crystalline center or nucleus inside the head from which it spreads outward as a smooth, bright, or dark, round or oval surface substantially at a right angle to the length of the rail. The distinguishing features of a transverse fissure from other types of fractures or defects are the crystalline center or nucleus and the nearly smooth surface of the development that surrounds it.
Transverse fissure defects are inherent from the manufacturing process and are found predominantly in non-control cooled rail prior to the mid-1930s. However, it can develop in more modern high-chrome rail from a hydrogen imperfection. It is not uncommon for multiple fissures to be present in one rail length. Identification of this type defect is not accurately made until the rail section is broken and the size determined by the area of cross-section of the rail head affected. It is normal for a transverse fissure to remain in service for some time without further development. Development is highly influenced by wheel impact and rail bending stresses, and growth is normally slow to a size encompassing 20-25% cross-sectional area of the rail head. Once the defect reaches this size, growth is normally more accelerated.

**Compound Fissure**


*Figure 14: Compound Fissure*

**Description –** Compound fissure means a progressive fracture originating from a horizontal split head that turns up or down, or in both directions, in the head of the rail. Transverse development normally progresses substantially at a right angle to the length of the rail.

The defect normally originates as a horizontal separation from an internal longitudinal seam, segregation, or inclusion inherent from the manufacturing process. It then develops longitudinally prior to transverse progression upward, downward, or in both directions in relation to the transverse plane of the rail section.

Growth is normally slow to a size of 30-35%. The compound fissure can result in an oblique type failure and is considered a hazardous rail defect.

**Detail Fracture**

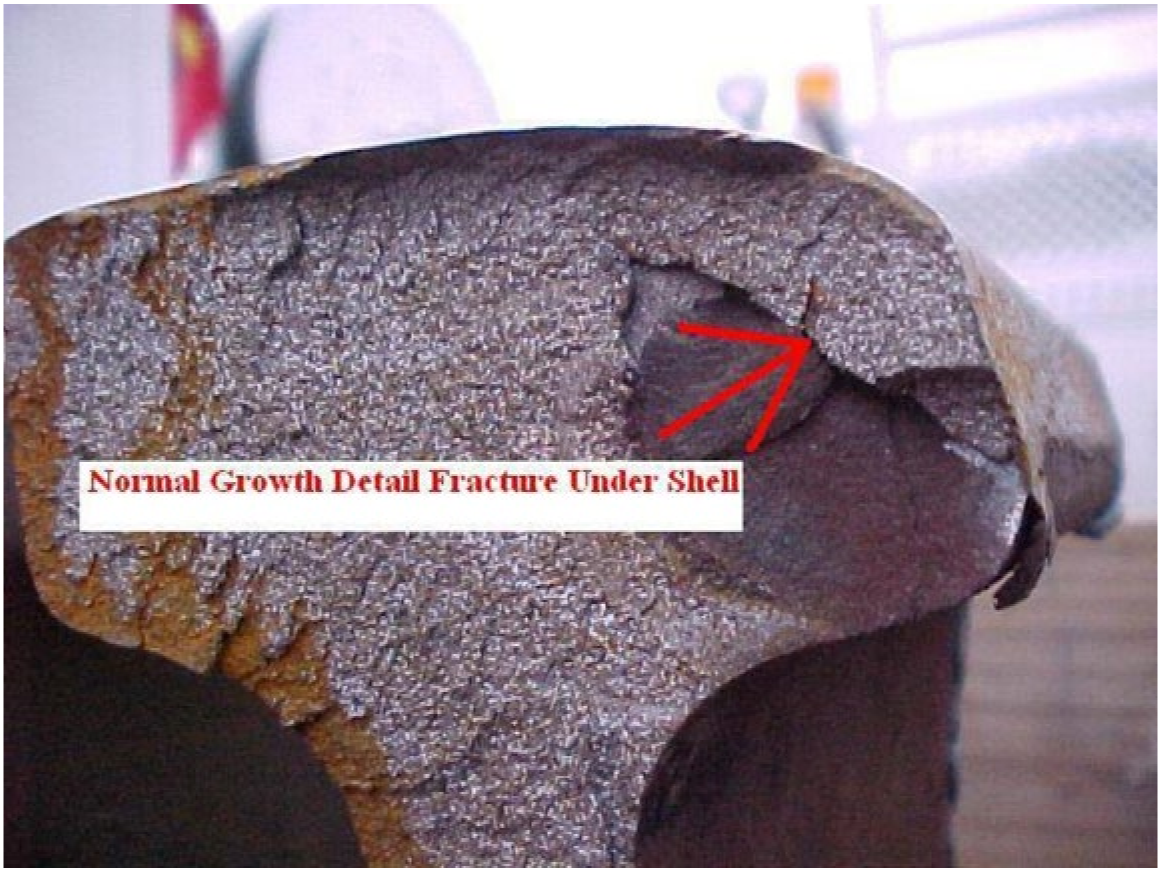


*Figure 15: Detail Fracture Originating from a Visible Shell*

**Description** – Detail fracture means a progressive fracture originating at or near the surface of the rail head. These fractures should not be confused with transverse fissures, compound fissures, or other defects, which have internal origins. Detail fractures may originate from shelly spots, head checks, or flaking.

The detail fracture is usually associated with the presence of a longitudinal seam or streak near the running surface on the gage side. Unlike the transverse fissure, no nucleus will be present. Growth can be normally slow to a size of a 10-15% cross-section of the rail head. Growth can then become rapid and/or sudden, prior to complete failure. It is not uncommon for more than one detail fracture to develop in an immediate area where the conditions that initiate their development, such as shelling or head checking, are present.

*Figure 16: Detail Fracture Originating from a Visible Shell*

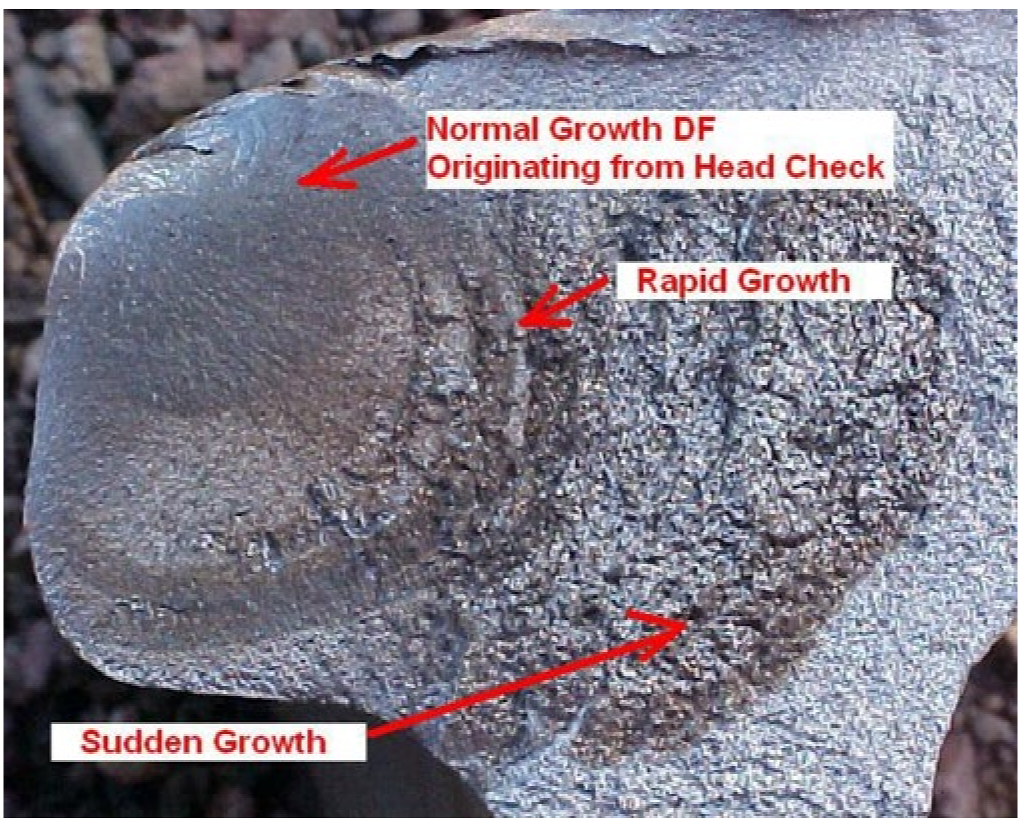

*Figure 17: Detail Fracture from Head Check*

The detail fracture from the head check is a progressive fracture initiating at the gage corner of the rail head and developing transversely in the head. The origin is a head check condition located at the upper gage corner of the rail, normally associated with concentrated loading which cold works the steel. This can also be referred to as a thermal crack. Growth can be very rapid after a size of 5-10 % cross sectional area of the rail head is reached.


*Figure 18: Reverse Detail Fracture*

The reverse detail fracture is a progressive transverse fracture normally originating at the bottom corner of the gage side of the rail head. The origin is a stress riser associated with a notching condition on the cold rolled lip located on the bottom corner of the rail head. The cold rolled lip condition is typically associated with severely worn rail and high axle loadings. The growth is normal to a size of 10% and is often rapid or sudden prior to complete failure of the rail section. It is not uncommon for complete failure at a size much less than that of a typical detail fracture type defect.

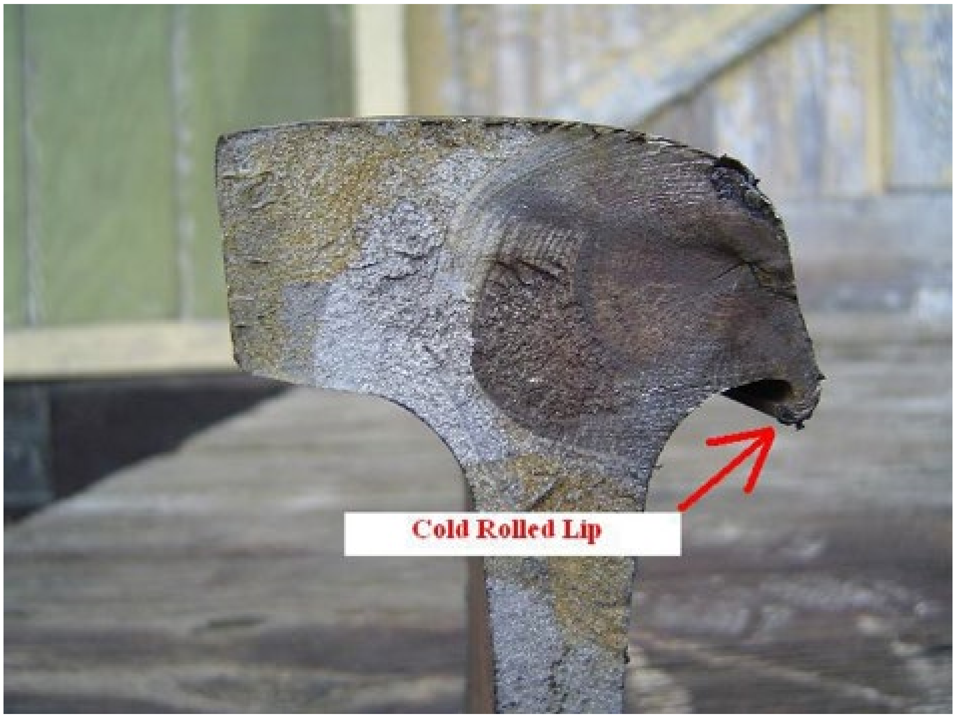


*Figure 19: Reverse Detail Fracture Showing Significant Development*

**Engine Burn Fracture**

*Figure 20: Engine Burn Fracture Showing Significant Growth*

**Description –** Engine burn fracture means a progressive fracture originating in spots where driving wheels have slipped on top of the rail head. In developing downward, they frequently resemble the compound or even transverse fissures with which they should not be confused or classified.

The defect originates when a slipping engine driver wheel heats a portion of the rail surface, and rapid cooling forms thermal cracks. Impact from wheels over the affected burned area initiates a slight horizontal separation of the burned metal from the parent rail metal and develops a flat spot. Transverse separation may start from a thermal crack in the region of the burn at any time.

It is common for more than one engine burn to be located within a short proximity. Growth is normally slow to a size of 10-15%. However, once transverse separation reaches a size of 10-15%, growth can become accelerated.

**Ordinary Break**

*Figure 21: Rail Failure Fracture Face Showing No Transverse Defect*

**Description –** Ordinary break means a partial or complete break in which there is no sign of a fissure, and in which none of the other defects described in this section is found.

In very cold weather, this type of rail fracture can occur as a result of a significant wheel impact from a flat or broken wheel. This type of failure can also be more susceptive to break where an unevenly supported base is present. The cause of failure cannot easily be determined.

**Longitudinal Defects in the Rail Head**
**Horizontal Split Head**

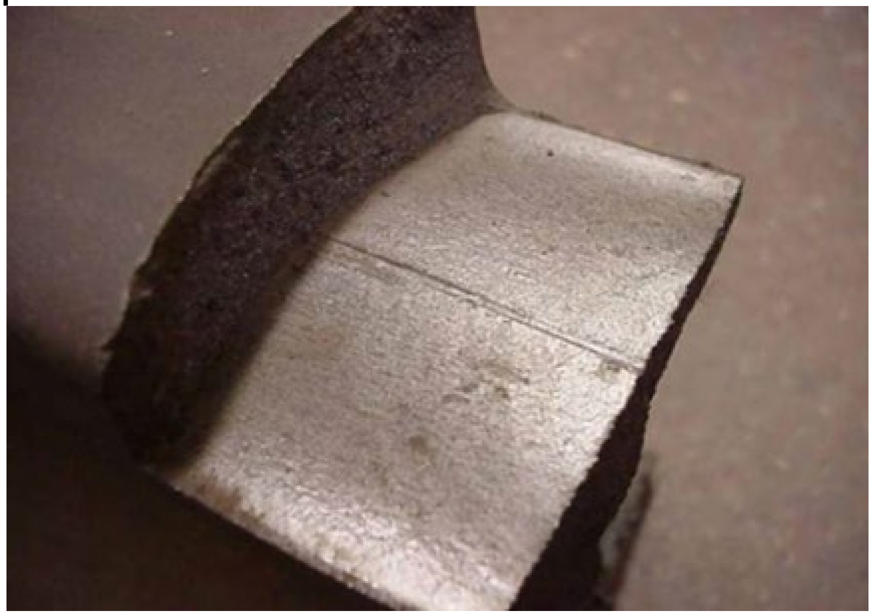

*Figure 22: Horizontal Split Head Originating from Internal Seam*

**Description –** Horizontal split head means a horizontal progressive defect originating inside of the rail head, usually one-quarter inch or more below the running surface and progressing horizontally in all directions, and generally accompanied by a flat spot on the running surface. The defect appears as a crack lengthwise of the rail when it reaches the side of the rail head.

The horizontal split head originates from an internal longitudinal seam, segregation, or inclu- sion inherent from the manufacturing process. Horizontal separation will progress longitudinally and horizontally (parallel to the running surface) and is normally rapid in development. Wheel impact can initiate transverse separation, in which case the defect should be classified as a compound fissure. The horizontal separation may be present in several locations within the same rail section.

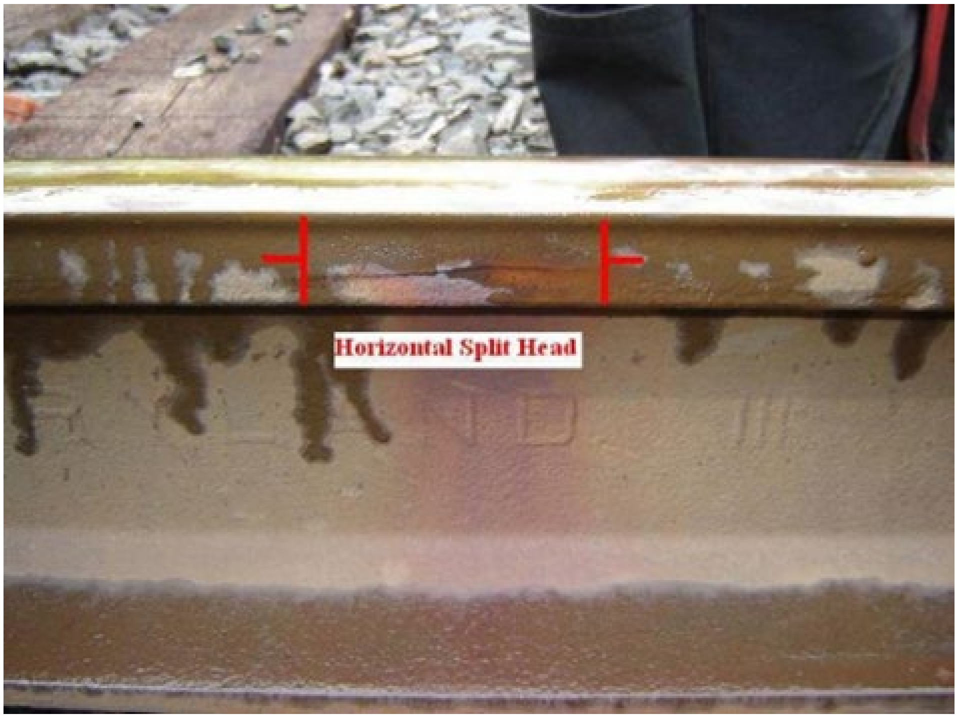


*Figure 23: Side View of Horizontal Split Head*

**Vertical Split Head**

*Figure 24: Vertical Split Head Defect Breaking Out in Head/Web Fillet Area*

**Description –** Vertical split head means a vertical split through or near the middle of the head, extending into or through it. A crack or rust streak may show under the head close to the web or pieces may be split off the side of the head.

The origin is an internal longitudinal seam, segregation, or inclusion inherent from the manufacturing process. Vertical separation will progress longitudinally and vertically (parallel to side of head), and may gradually turn toward the gage or field side of the rail head. It is common for a portion of a vertical split head to develop toward the gage side of the rail head while the other end develops toward the field side.

Growth is normally very rapid once the seam or separation has opened up anywhere along its length.

The vertical split head defect can be identified by the presence of a dark streak on the running surface and widening of the head for the length of the defect development. The side of the head to which the split is offset may show signs of sagging or dropping, and a rust streak may be present in the head/web fillet area under the rail head. In advanced stages, a bleeding crack will be apparent at the fillet.

*Figure 25: Vertical Split Head Crack Out in Head/Web Fillet Area*


*Figure 26: Vertical Split Head (Shear Break)*

A shear break is a longitudinal separation of the rail head, resulting from the loss of significant rail head parent metal. The reduction of rail head parent metal results in the loss of the ability of the rail section to support loading and is not typically associated with inherent conditions in the material. A shear break usually occurs when the rail is loaded off the center axis, causing rail head collapse, and can be associated with gaging problems, light weight rail, severely worn (vertical wear) rail, or off-center loads caused by worn rolling stock wheels.

Growth is usually very sudden, and more than one shear break may be present in the immediate vicinity as a result of the significant weakness of the rail head. Visual characteristics are the same as a vertical split head and it is classified as a vertical split head defect when discovered.

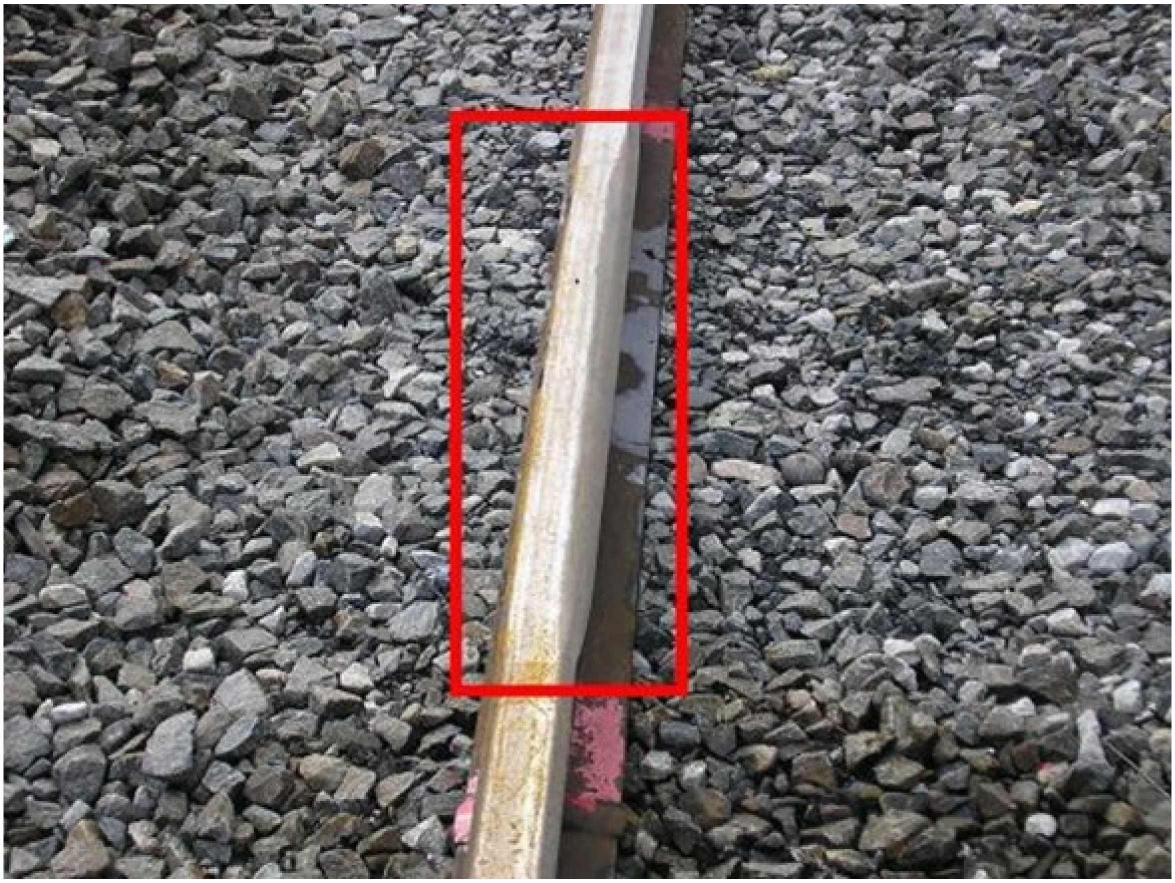
Figure 27: Shear Break Showing Dark Discoloration Identifying Defect Length

**Web Defects**
**Head and Web Separation**


*Figure 28: Head and Web Separation Showing Progression into Web*

**Description –** Head and web separation means a progressive fracture longitudinally separating the head and web of the rail at the fillet under the head.

Acidic action from some asphalt-based fill material, used in road crossings, may initiate a corrosion fatigue where the rail head joins the web. Gravel in crossings, excessive speed on curves, or improper canting of the rail can cause eccentric loading of the rail head and initiate development. Fatigue development can appear as rust-colored “rail strain” in the head/web fillet area, or as a slight horizontal cracking under the head. This type of defect can also develop in the head fillet area at the jointed rail end as a result of extreme stress conditions often created by pumping or swinging joints.

*Figure 29: Head and Web Defect Associated with Rail Joint*

**Split Web**

*Figure 30: Split Web Defect Showing Bleeding Condition Along Crack Development*

**Description –** Split web means a lengthwise crack along the side of the web, extending into or through it. The origin can be a seam or damage to the web, mechanical damage, or the split web can sometimes develop at locations where heat numbers are stamped into the web. Split webs can also develop as a result of high residual stresses from the roller straightening process, rail welding, and joint application.

Growth can be very rapid once the crack extends through web. It can also be accelerated by heavy axle loading. The defect can be visibly identified by the presence of rust-colored bleeding along the crack development.

*Figure 31: Web Failure Resulting from High Residual Stress*

**Piped Rail**

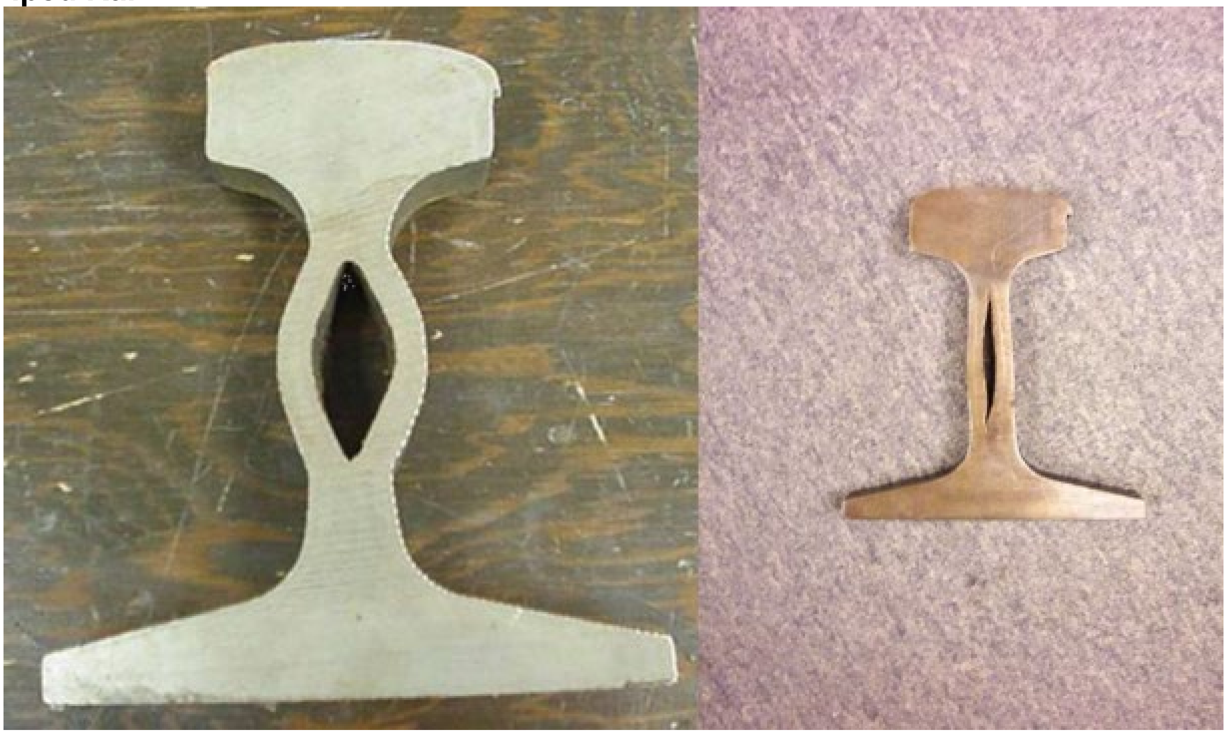

*Figure 32: Piped Rail Showing Significant Rail Collapse*

**Description –** Piped rail means a vertical split in a rail, usually in the web, due to failure of the shrinkage cavity in the ingot to unite in rolling.
The origin of a piped rail is normally from the presence of a longitudinal seam or cavity inside the web that is inherent from the manufacturing process. Once development initiates, the seam will develop vertically toward the head and base of the rail. This type of defect is relatively uncommon in modern rail manufacturing technology.
The original seam does not normally progress either vertically or horizontally. Heavy axle loading can result in the seam spreading or opening up in a crosswise direction, resulting in a bulge in the web. These internal seams are also susceptible to development when subjected to pressure butt welding.

**Miscellaneous Defects**
**Broken Base**

*Figure 33: Base Defect Originating from an Identifiable Nick on Bottom of Rail*

*Figure 34: Half-Moon-Shaped Broken Base*

**Description –** Broken base means any break in the base of the rail. Broken base is generally categorized into two types of failure: broken base and base fracture. A broken base is normally confined within the flange area of the rail base and is normally an oval-shaped break referred to as a “half moon” break. This type of base break is commonly caused by a seam, segregation, or improper bearing on the tie plate. A base fracture is normally the result of a nick or other type damage to the base that results in an identifiable indentation.

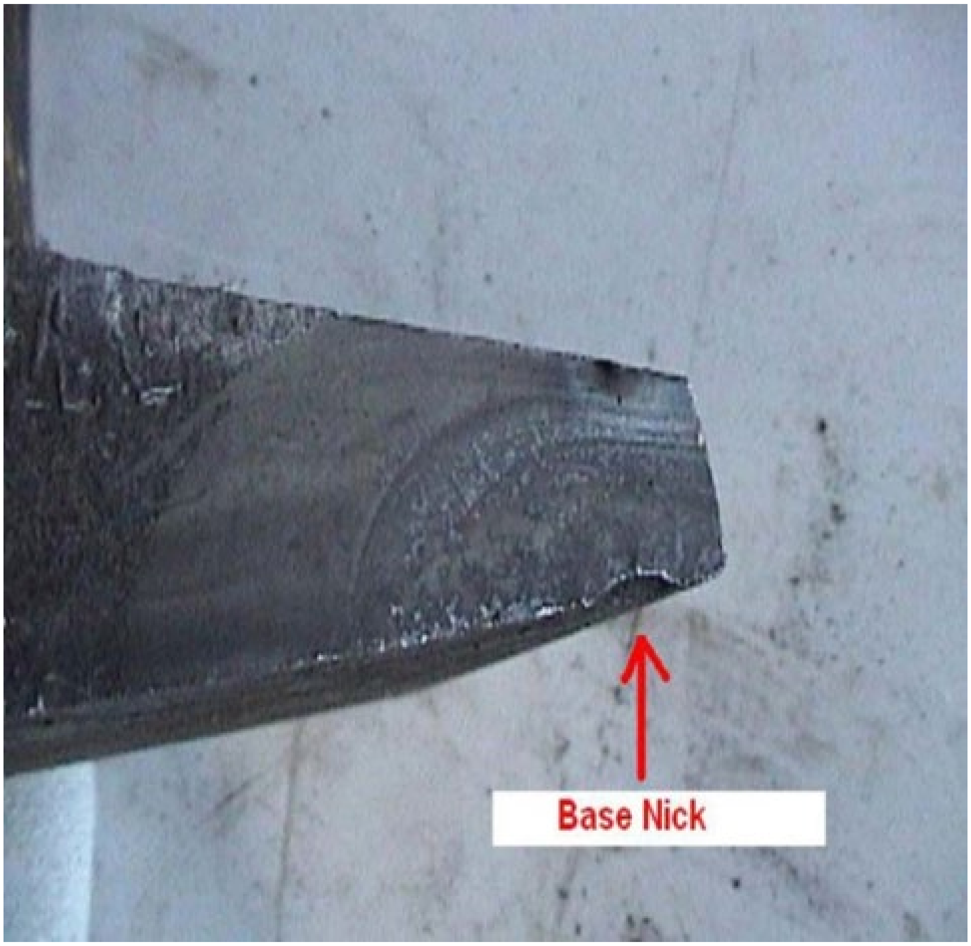


*Figure 35: Base Fracture Showing Nick with Transverse Development*

A base fracture is a progressive fracture in the base of the rail, which can develop in a transverse plane. These defects, as a rule, originate on the outer edge of the base and can result in complete transverse failure of the rail section. Base fractures are usually caused by a nick on or a blow to the edge of the base, which results in an indentation or similar damage. Damage of this nature is sometimes caused by improper rail handling. Transverse development can be relatively slow until the defect has progressed some distance into the rail section. However, a complete and sudden transverse rupture of the rail can occur with minimal transverse progression.

**Defective Weld**


*Figure 36: Electric Flash Butt Weld Showing Oxide Entrapment and Progression*

**Description –** Defective weld means a field or plant weld containing any discontinuities or pockets, exceeding 5% of the rail head area individually or 10% in the aggregate (oriented in or near the transverse plane) due to incomplete penetration of the weld metal between the rail ends, lack of fusion between weld and rail end metal, entrainment of slag or sand, underbead or other shrinkage cracking, or fatigue cracking. Weld defects may originate in the rail head, web, or base, and in some cases, cracks may progress from the defect into either or both adjoining rail ends. If the weld defect progresses longitudinally through the weld section, the defect is considered a split web for purposes of remedial action.

Plant welds are identifiable as a result of the shearing processes used to remove excessive weld material. This removal will provide a finish that is flusher with the web design, as opposed to field welds that will show excess weld material along the web and base area of the rail. Both types of welds can also fail at an angular or oblique direction from an anomaly associated with the web area such as shear gouges, trapped oxides, or improper heat.


*Figure 37: Thermite Weld with Slag Entrapment*


*Figure 38: Thermite Weld Showing Severe Porosity*


*Figure 39: Thermite Weld Showing Oblique Type Failure Originating in Web Area*

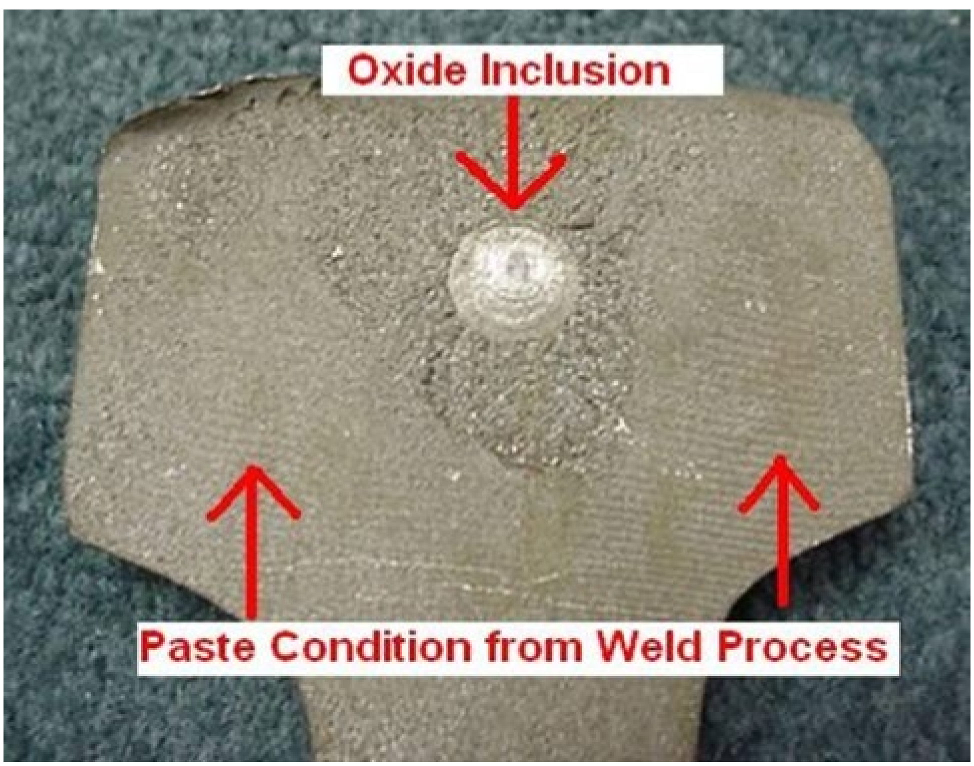


*Figure 40: Gas Pressure Weld Showing Oxide Inclusion and Improper Fusion*

**Detail Fracture Associated with Welded Bond Wire Connection (Traction, Signal)**

*Figure 41: Transverse Defect Developing from Bond Application*

**Description –** A welded bond wire connection can be the origin of a transverse defect that develops and expands from the point on the rail head where a head bond is attached by welding. It is questionable whether the primary cause of transverse defects associated with welded bonds is due to thermal cracks being created by rapid or irregular cooling at or near the point where the bond is attached or whether the focal point of the defect is a metallurgic reaction and the resulting penetration of the native metal through a martensite layer sometimes developed between the bond and the rail head. The inspector should be aware that rail defects can also develop from bond applications to the rail web.

*Figure 42: Web Defect Developing from Bond Application*

**Bolt Hole Crack**


*Figure 43: Bolt Hole Crack Originating in Lower Quadrant with Significant Progression*

**Description –** Bolt hole crack means a crack across the web, originating from a bolt hole, and progressing on a path either inclined upward toward the rail head or inclined

downward toward the base. Fully developed bolt hole cracks may continue horizontally along the head/web or base/web fillet, or they may progress into and through the head or base to separate a piece of the rail end from the rail. Multiple cracks occurring in one rail end are considered to be a single defect. However, bolt hole cracks occurring in adjacent rail ends within the same joint must be reported as separate defects.
A bolt hole crack is normally the result of stresses associated with pumping or swinging joints, improper drilling, excessively worn joint bars, or abnormal rail end impacts from rolling stock. Unchamferred holes that result a drilling burr on the edge of the hole left by the drilling operation can result in defect development. Growth is normally erratic, and the rail can frequently rupture from a very small defect when the rail end is subjected to unusual stresses.

**Flattened Rail**

*Figure 44: Flattened Rail*

**Description –** Flattened rail means a short length of rail, not at a joint, that has flattened out across the width of the rail head to a depth of 3/8 inch or more below the rest of the rail and 8 inches or more in length. Flattened rail occurrences have no repetitive regularity and thus do not include corrugations and have no apparent localized cause such as a weld or engine burn. Their individual lengths are relatively short, as compared to a condition such as head flow on the low rail of curves.

**Damaged Rail**

*Figure 45: Damaged Rail*

**Description –** Damaged rail means any rail broken or injured by wrecks, broken, flat, or unbalanced wheel, wheel slipping, or similar causes.

**Crushed Head**

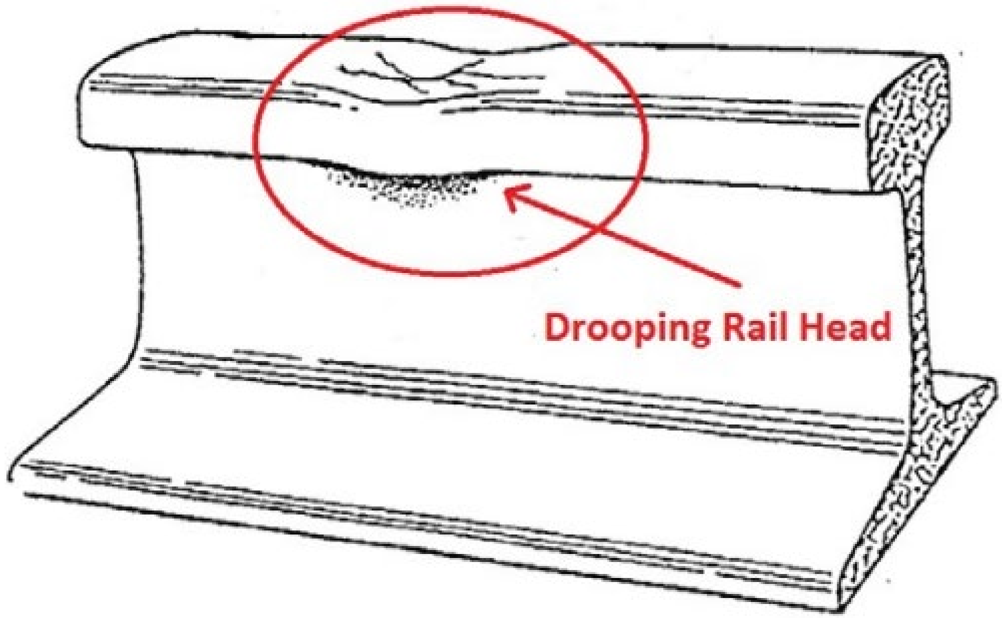


*Figure 46: Example of Drooping Rail Head*

**Description –** Crushed head means a short length of rail, not at a joint, which has drooped or sagged across the width of the rail head to a depth of three-eighths inch or more below the rest of the rail head and 8 inches or more in length. Unlike flattened rail, where the depression is visible on the rail head only, the sagging or drooping is also visible in the head/web fillet area.

## ROLLING CONTACT FATIGUE

Rolling contact fatigue (RCF) conditions develop in rails at the wheel/rail interface in most railroad systems. Any type of surface condition can be an influential obstacle in the detection of an underlying rail defect. If any doubt or uncertainty in the integrity of the test process is identified by the detector car operator concerning surface conditions, they have the option to record the rail section as an invalid test and report the location to the railroad. Detailed below are some of the more critical types of surface conditions we encounter.

**Shells**

Shells are identified as progressive horizontal separations, generally on the gage side of the rail head, which may crack out at any level, usually at the upper gage corner. Shelling may turn down to form a transverse separation and, once detected, is classified as a detail fracture. Uncapped or gutted shells will result in the dislodgement of parent metal from the rail section.

*Figure 48: Gage Side Shell Showing Severe Parent Metal Decay*

**Flaking**

Flaking originates at the surface of the rail and is commonly found near the stock rail area of a switch where concentrated loading cold works the steel. Flaking can be identified on the rail head surface as a horizontal separation with scaling or chipping of small segments of parent metal.

*Figure 49: Centralized Flaking Condition Showing Chipping of Parent Metal*

**Burned Rail**

Burned rail is a rail head condition that is the result of friction from slipping locomotive drivers. The damaged area can gradually chip out and roughen under repeated traffic. Potential transverse defects can develop from thermal cracks associated with the burned area. Once the surface condition reaches a critical stage of displacement of the rail head surface material, the detection of an underlying rail flaw is obstructed.

*Figure 50 Thermal Cracks on Burned Stock Rail*

**Head Checking**

Head checking is identified as a slight separation of metal on the gage side of the rail head, normally found in the high side of curves. It is also common in switch areas, due to the lateral force induced on the rail head from wheel displacement through turnouts. Head checking can turn down and develop into a transverse separation.

*Figure 51: Gage Side Head Checking and Flaking*

**Spalling**

Spalling is generally referred to as the displacement of parent metal from the rail head from high contact stresses associated with cyclical loading. This may also be referred to as a slight flaking in the minimal stage of severity. Further deterioration of the rail head can increase the amount of metal displacement, resulting in a significant spalling condition.


*Figure 52: Flattened Rail Head Showing Displacement of Parent Metal (Spalling)*

Note: It is the responsibility of the rail flaw detector car operator to properly identify the types of rail head surface conditions that can result in an improper or invalid test of the rail section in which the condition is contained. Extra care should be taken within interlocking areas. The operator should also be aware of other conditions that can result in an invalid test.

**Effects of Rail Wear**

Severe head wear distortion can alter the normal angle refraction of the ultrasonic beam from the transducer to such a critical level that the ultrasonic signals do not penetrate at the expected angle, or to the expected location, in the specimen. Therefore, it is possible that reflected sound beams normally associated with internal rail flaws may not be identified by the test system from the defective portion of the rail section. In effect, if the severity of the head wear characteristics is significant, it can impact the integrity of the test.

**Rail Flaw Development and Failure**

Nondestructive test systems are designed to perform optimally on a perfect test specimen. Unfortunately, much of the rail in the heavy haul industry is affected by the loading stresses that result in much of the plastic deformation characteristics of the rail specimen that were previously described. These conditions impact the development of rail flaws. The conditions can also impact the technologies currently used for flaw detection and limit their detection capabilities. Therefore, it is important that emerging technology developments continue in an effort to alleviate the impact of adverse test specimen conditions.

Normal railway maintenance such as rail lubrication, rail profile maintenance, and track maintenance programs, all greatly increase the life cycle of rail. These practices also are deterrents to the crack growth life of internal rail flaws. Without aggressive track maintenance programs, rail flaw development and failure will continue to be an issue and result in service disruption to the heavy haul railways.

# 49 CFR §213.113 Defective Rails

(a) When an owner of track learns that a rail in the track contains any of the defects listed in the table contained in paragraph (c) of this section, a person designated under § 213.7 shall determine whether the track may continue in use. If the designated person determines that the track may continue in use, operation over the defective rail is not permitted until -

1) The rail is replaced or repaired; or
2) The remedial action prescribed in the table contained in paragraph (c) of this section is initiated.

(b) When an owner of track learns that a rail in the track contains an indication of any of the defects listed in the table contained in paragraph (c) of this section, the track owner shall verify the indication. Except as provided in § 213.240, the track owner must verify the indication within four hours, unless the track owner has an indication of the existence of a defect that requires remedial action A, A2, or B identified in the table contained in paragraph (c) of this section, in which case the track owner must immediately verify the indication. If the indication is verified, the track owner must -

1) Replace or repair the rail; or
2) Initiate the remedial action prescribed in the table contained in paragraph (c) of this section.

(c) A track owner who learns that a rail contains one of the following defects shall prescribe the remedial action specified if the rail is not replaced or repaired, in accordance with this paragraph's table:

| Defect | Percent/length of defect | If the defective rail is not replaced or repaired, take the remedial action prescribed in note |
|---|---|---|
| **Compound Fissure** | 5-70% | B |
| | 70-100% | A2 |
| | 100% | A |
| **Transverse Fissure<br>Detail Fracture<br>Engine Burn Fracture<br>Defective Weld** | 5-25% | C |
| | 25-60% | D |
| | 60-100% | A2, or [E and H] |
| | 100% | A, or [E and H] |
| **Horizontal split head<br>Vertical split head<br>Split Web<br>Piped Rail<br>Head Web Separation<br>Defective Weld** | 1-2” | H and F |
| | 2-4” | I and G |
| | 4”- | B |
| | Breakout in rail head | A |
| **Bolt Hole Crack** | ½-1” | H and F |
| | 1-1 ½” | H and G |
| | 1 ½”- | B |
| | Breakout in rail head | A |

| | | |
|---|---|---|
| **Broken Base**[2] | 1-6” | D |
| | 6”- | A, or [E and H] |
| **Ordinary Break** | | A or E |
| **Damaged Rail** | | C |
| **Flattened Rail Crushed head** | Depth ≥3/8” Length ≥8” | H |

[2] Remedial action D applies to a moon-shaped breakout, resulting from a derailment, with length greater than 6 inches, but not exceeding 12 inches and width not exceeding one-third of the rail base width.

Notes:

A. Assign a person designated under § 213.7 to visually supervise each operation over the defective rail.

A2. Assign a person designated under § 213.7 to make a visual inspection. After a visual inspection, that person may authorize operation to continue without continuous visual supervision at a maximum of 10 m.p.h. for up to 24 hours prior to another such visual inspection or replacement or repair of the rail.

B. Limit operating speed over the defective rail to that as authorized by a person designated under § 213.7(a), who has at least one year of supervisory experience in railroad track maintenance. The operating speed cannot be over 30 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower.

C. Apply joint bars bolted only through the outermost holes to the defect within 10 days after it is determined to continue the track in use. In the case of Class 3 through 5 track, limit the operating speed over the defective rail to 30 m.p.h. until joint bars are applied; thereafter, limit the speed to 50 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower. When a search for internal rail defects is conducted under § 213.237, and defects are discovered in Class 3 through 5 track that require remedial action C, the operating speed shall be limited to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower, for a period not to exceed 4 days. If the defective rail has not been removed from the track or a permanent repair made within 4 days of the discovery, limit operating speed over the defective rail to 30 m.p.h. until joint bars are applied; thereafter, limit speed to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower. When joint bars have not been applied within 10 days, the speed must be limited to 10 m.p.h. until joint bars are applied.

D. Apply joint bars bolted only through the outermost holes to the defect within 7 days after it is determined to continue the track in use. In the case of Class 3 through 5 track, limit operating speed over the defective rail to 30 m.p.h. or less as authorized by a person designated under § 213.7(a), who has at least one year of supervisory experience in railroad track maintenance, until joint bars are applied; thereafter, limit speed to 50 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower. When joint bars have not been applied within 7 days, the speed must be limited to 10 m.p.h. until the joint bars are applied.

E. Apply joint bars to the defect and bolt in accordance with § 213.121(d) and (e).

F. Inspect the rail within 90 days after it is determined to continue the track in use. If the rail remains in the track and is not replaced or repaired, the re-inspection cycle starts over with each successive re-inspection unless the re-inspection reveals the rail defect to have increased in size and therefore become subject to a more restrictive remedial action. This process continues indefinitely until the rail is removed from the track or repaired. If not inspected within 90 days, limit speed to that for Class 2 track or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower, until it is inspected.

G. Inspect rail within 30 days after it is determined to continue the track in use. If the rail remains in the track and is not replaced or repaired, the re-inspection cycle starts over with each successive re-inspection unless the re-inspection reveals the rail defect to have increased in size and therefore become subject to a more restrictive remedial action. This process continues indefinitely until the rail is removed from the track or repaired. If not inspected within 30 days, limit speed to that for Class 2 track or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower, until it is inspected.

H. Limit operating speed over the defective rail to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.

I. Limit operating speed over the defective rail to 30 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower

In paragraph (a), FRA explains that only a person qualified under §213.7, is able to determine that a track may continue to be used once a defective rail (as defined in this section) is identified, regardless of the method by which it was identified. The option "or repaired" in paragraph (a)(1) allows railroads to use recently developed rail head removal and replacement processes to remove just the defective portion of the rail section. This process is used to remove transverse defects or some types of defective welds, by using recently developed weld technologies. These processes. when used correctly, allow the remaining non-defective portion of the rail to remain in the track. Paragraph (b) provides that track owners have up to a 4-hour period (except as provided in section 213.240 – Continuous Testing) in which to verify that certain suspected defects exist in a rail section, once they learn that the rail indicates any of the defects identified in paragraph (c)'s remedial action table. This 4-hour deferred verification period applies only to suspected defects that may require remedial action Notes "C" through "I," found in the remedial action table. This 4-hour period does not apply to suspected defects that may require remedial action Notes "A," "A2," or "B," which are more serious and must be verified immediately.

The 4-hour timeframe provides flexibility to allow the rail flaw detector car to continue testing in a limited non-stop mode, without requiring verification of less serious, suspected defects that may require remedial action under notes “C” through “I.” This flexibility also helps to avoid the need to operate the detector car in a non-test, “run light” mode over a possibly severe defective rail condition that could cause a derailment, when having to clear the track for traffic movement. However, any suspected defect encountered that may require remedial action notes “A,” “A2”, or “B” requires immediate verification. Overall, the four-hour, deferred-verification period is intended to help to improve rail flaw detector car utilization, allows operation of the chase car test method, increase the opportunity to detect more serious defects, and ensure that entire rail a detector car is intended to travel over while in service is inspected.

Paragraph (c) contains both the remedial action table and its notes. The remedial actions required for defective rails are outlined based on circumstances and the time limits and speeds are based on the severity of the defect. The intent is to provide a logical balance between preventing the likelihood for a rail failure and operational disruptions that negatively affect the movement of goods and people.

The remedial actions also allow certain discretion to the track owner for the continued operation over certain defects. Inspectors should consider all rail defects dangerous and care should be taken to determine that proper remedial actions have been accomplished by the track owner of the railroad. When more than one defect is present in a rail, the defect requiring the most restrictive remedial action shall govern.

The remedial action table and specifications in the rule address the risks associated with rail failure. These risks are primarily dependent upon defect type and size and should not be dependent upon the manner or mechanism that reveals the existence of the defect. Failure of the track owner to comply with the operational (speed) restrictions, maintenance procedures, and the prescribed inspection intervals specified in this section and § 213.237 or § 213.240, may result in a violation of the Track Safety Standards (TSS).

Note “A” clarifies that a person qualified to supervise certain renewals and inspect track as designated in § 213.7 must visually supervise each operation over the defective rail.

Note “A2” addresses mid-range transverse defect sizes. This remedial action allows for train operations to continue at a maximum of 10 mph for up to 24 hours, following a visual inspection by a person designated under § 213.7. If the rail is not repaired or replaced, another 24-hour cycle begins.

Note “B” limits the speed to that as authorized by a person designated under § 213.7(a) who has at least 1 year of experience in track maintenance. The qualified person has the responsibility to evaluate the rail defect and authorize the maximum operating speed over the defective rail based on the size of the defect and the operating conditions; however, the maximum speed over the rail may not exceed 30 mph or the maximum speed under

§213.9 for the class of track concerned (whichever is lower). This remedial action relies on the training, experience, and good judgement of the qualified person to appropriately determine what speed, if any, trains may safely be allowed to operate over a rail defect under this designation.

Notes “C,” “D,” and “H” limit the operating speed, following the application of joint bars, to 50 mph or the maximum allowable speed under § 213.9 for the class of track concerned (whichever is lower). When the maximum speed specified in Notes “B,” “C,” “D,” and “H” exceeds the current track speed, the railroad is still required to record that the defect exists, and what initial remedial action was applied. For example, when a railroad determines that remedial action Note “B” is required and the track speed already is 30 mph or less, the railroad must record the defect. This indicates that the railroad is aware of the characteristics of the defective rail and has designated a permissible speed in compliance with the regulation’s remedial actions.

Note “C” applies specifically to detail fractures, engine burn fractures, transverse fissures, and defective welds, and addresses defects that are discovered during an internal rail inspection conducted per § 213.237 or § 213.240 and whose size is determined to be less than 25 percent of the rail head cross-sectional area.

Note “C” requires a track owner to apply joint bars bolted only through the outermost holes to the defect within 10 days after it is determined to continue the track in use. When joint bars have not been applied within 10 days, the track speed must be limited to 10 mph until joint bars are applied. This allows the railroads alternative relief from remedial action for these types of defects in Class 1 track.

Note “D” applies specifically to detail fractures, engine burn fractures, transverse fissures, and defective welds, and addresses defects that are discovered during an internal rail inspection conducted per § 213.237 or § 213.240 and whose size is determined not to be equal to or greater than 60 percent of the rail head cross-sectional area.

Note “D” requires a track owner to apply joint bars bolted only through the outermost holes to the defect within 7 days after it is determined to continue the track in use. The allowance of 7 days provides the track owner with additional time for remediation when the defect is identified just prior to the start of weekend shutdown. When joint bars have not been applied within 7 days, the track speed must be limited to 10 mph until joint bars are applied. As mentioned in Note “C,” this addition also allows the railroads alternative relief from remedial action for these types of defects in Class 1 track.

When an FRA inspector discovers a defective rail that requires the railroad representative to determine whether to continue the track in use and to designate the maximum speed over the rail, the inspector should inquire as to the representative’s knowledge of the defect and remedial action. If the railroad was not aware of the defect prior to the FRA inspection, the FRA inspector should observe the actions taken by the railroad representative to determine compliance. If the railroad had previously found the defective rail, the FRA inspector should confirm the proper remedial action was taken. During records inspections, the FRA inspector should confirm that the defects were recorded and proper remedial actions were taken.

The remedial action table for defects failing in the transverse plane (transverse and compound fissures, detail and engine burn fractures, and defective welds) specifies a lower limit range base of 5 percent of the railhead cross-sectional area. If a transverse defect is reported to be less than 5 percent, the track owner is not required to provide corrective action under the TSS. Conditions reported to be less than 5 percent are not consistently found during rail breaking routines and therefore defect determination within this range is not always reliable.

Compound fissure defects that weaken at least 5 but less than 70 percent of cross-sectional of the rail head area are defects requiring remedial action (Note B). Defects equal to or greater than 70 but less than 100 percent of cross-sectional head area require remedial action (Note A2), as prescribed. Defects that affect 100 percent of the cross-sectional head area require remedial action (Note A) as prescribed, the most restrictive remedial actions. Inspectors should be aware that compound fissures are defects that can fail in the transverse or oblique plane and are characteristic of rail that has not been control-cooled (normally rolled prior to 1936).

Defects identified and grouped as detail fractures, engine burn fractures, transverse fissures, and defective welds, will weaken and will normally fail in the transverse plane. Their prescribed remedial action relates to a low range at least 5 but less than 25 percent and a mid-range at least 25 but less than 60 percent, for Notes “C” and “D,” respectively. Those defects require joint bar applications and operational speed restrictions within certain time frames. Defects extending less than 100 but at least 60 percent require a visual inspection. If the rail is not replaced, effectively repaired, or removed from service, an elective would be to restrict operation to a maximum of 10 mph for up to 24 hours, then perform another visual inspection.

The second part of remedial action Note “C,” starting with the second sentence, addresses defects that are discovered in Classes 3 through 5 track during an internal rail inspection required under § 213.237, and which are less than 25 percent of the rail head crosssectional area. For these specific defects, a track owner may operate for a period not to exceed 4 days, at a speed limited to 50 mph or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower. If the defective rail is not removed or a permanent repair is not made within 4 days of discovery, the speed is limited to 30 mph for up to 10 days from discovery. If joint bars have not been applied within 10 days, speed shall be restricted to 10 mph until joint bars are applied or the rail is replaced.

The requirements specified in this second part of remedial action Note “C” are intended to promote better usage of rail inspection equipment and therefore maximize the opportunity to discover rail defects, which are approaching service failure size. The results of FRA’s research indicate that defects of this type and size range have a predictable slow growth life. Research further indicates that even on today's most heavily used trackage in use today, defects of this type and size are unlikely to grow to service failure size in 4 days.

In the remedial action table, all longitudinal defects are combined within one group subject to identical remedial actions based on their reported size. These types of longitudinal defects all share similar growth rates and the same remedial actions are appropriate to each type.

Defective rails categorized as horizontal split head, vertical split head, split web, piped rail, and head-web separation, and defective weld (longitudinal) are longitudinal in nature. When any of this group of defects is more than 1 inch, but not more than 2 inches, the remedial action initiated, under Note "H," is to limit train speed to 50 mph, and Note "F" requires re-inspecting the rail in 90 days, if deciding operations will continue. If not inspected within 90 days, speeds must be limited to that for Class 2 track or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower, until it is inspected.

Defects in the range of more than 2 inches, but not more than 4 inches, require complying with Notes "I" and "G," limiting speeds to 30 mph and requiring the rail be re-inspected in 30 days, if they decide operations will continue. If not inspected within 30 days, speed is limited to that for Class 2 track or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower, until it is inspected. When any of the six defect types exceed a length of 4 inches, remedial action Note "B" is required and speed must be limited to that authorized by a person designated under § 213.7(a), but cannot exceed 30 mph or the maximum allowable under § 213.9 for the class of track concerned, whichever is lower.

A "bolt hole crack" is a progressive fracture originating at a bolt hole and extending away from the hole, usually at an angle. It develops from high stress risers, usually initiating as a result of both dynamic and thermal responses of the joint bolt and points along the edge of the hole, under load. A major cause of this high stress is improper field drilling of the hole. Excessive longitudinal rail movement can also cause high stress along the edge of the hole.

Under Notes "H" and "F," the remedial action for a bolt hole crack that is more than one-half of an inch, but not more than 1 inch, if the rail is not replaced—is to limit speed to 50 mph, or the maximum allowable under § 213.9 for the class of track concerned, whichever is lower, then re-inspect the rail in 90 days, if operations will continue.

For bolt hole cracks greater than 1 inch, but not exceeding 1½ inches, Notes "H" and "G" apply. These rails are required to be limited to 50 mph, or the maximum allowable speed under §213.9 for the class of track concerned whichever is lower, and re-inspected within 30 days. For a bolt hole crack exceeding 1½ inches, Note "B" applies and a person qualified under §213.7(a) may elect to designate a speed restriction, which cannot exceed 30 mph, or the maximum allowable under § 213.9 for the class of track concerned, whichever is lower.

Under Notes “F” and “G,” where corrective action requires rail to be re-inspected within a specific number of days after discovery, several options for compliance may be exercised depending on the nature of the defect. For those defects that are strictly internal and are not yet visible to the naked eye, the only option would be to perform another inspection with rail flaw detection equipment, either rail-mounted or hand-held. For defects that are visible to the naked eye and therefore measurable, a visual inspection or an inspection with rail flaw detection equipment are acceptable options. For certain defects enclosed within the joint bar area, such as bolt hole cracks and head-web separations, the joint bars must be removed if a visual re-inspection is to be made.

The re-inspection prescribed in Notes “F” and “G” must be performed prior to the expiration of the 30- or 90-day interval. If the rail remains in track and is not replaced or repaired, the re-inspection cycle starts over with each successive re-inspection unless the re-inspection reveals that the rail defect to have increased in size and has therefore become subject to a more restrictive remedial action. This process continues indefinitely until the rail is removed from track.

A broken base can result from improper bearing of the base on a track spike or tie plate shoulder, and from over crimped anchors, or it may originate in a manufacturing flaw. With today’s higher axle loads, inspectors can anticipate broken base defects in 75-pound, and smaller, rail sections with an irregular track surface, especially on the field side. For any broken base discovered that is more than 1 inch, but less than 6 inches in length, the remedial action (Note “D”) is to apply joint bars bolted through the outermost holes to the defect within 10 days, if operations will continue. In Classes 3 through 5 track, the operating speed must be reduced to 30 mph or less, as authorized by a person under § 213.7(a), until joint bars are applied. After that, operating speed is limited to 50 mph or the maximum allowable under § 213.9 for the class of track concerned, whichever is lower.

Under Notes “C” and “D,” there are several acceptable “outermost” bolting arrangements for joint bars centered on a rail defect. The Figure below illustrates acceptable bolting arrangements. In all cases, railroads may not drill a bolt hole next to a defect that is being remediated with the application of joints bars (pursuant to Notes “C” and “D”). The reason for not drilling next to the defect is to prevent the propagation of the crack into the hole closest to the defect.

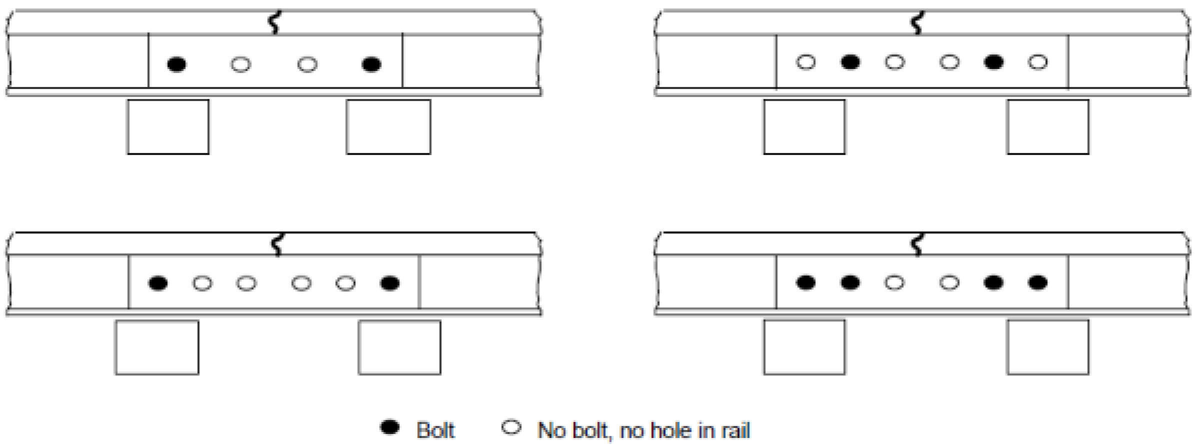


Figure 53: Acceptable "outermost" Bolting Arrangements

A broken base in excess of 6 inches requires the assignment of a person designated under §213.7 to visually supervise each train operation over the defective rail. The railroad may apply joint bars to the defect and bolt them in accordance with §§ 213.121(d) and (e), and thereafter must limit train operations to 30 mph or the maximum allowable under § 213.9 for the class of track concerned, whichever is lower. As reference, the dimensions between the outermost holes of a 24-inch joint bar vary between approximately 15 and 18 inches, and a 36-inch joint bar approaches 30 inches.

Inspectors should point out to the track owner that broken bases nearing these dimensions may negate the purpose for which the joint bars are applied. A broken base rail may be caused by damage from external sources, such as rail anchors being driven through the base by a derailed wheel. It is improper to consider them “damaged rail,” as this defect is addressed by more stringent provisions applicable to broken base rails, under Note “A,” or Notes “E” and “I.”

Damaged rail can result from flat or broken wheels, incidental hammer blows, or derailed or dragging equipment. Reducing the operational speed in Classes 3 through 5 track to 30 mph until joint bars are applied lessens the impact force imparted to the weaken area. Applying joint bars under Note “C” ensures a proper horizontal and vertical rail end alignment in the event the rail fails.

Flattened rails and crushed rails (localized collapsed head rail) are also caused by mechanical interaction from repetitive wheel loadings. FRA and industry research indicate that these occurrences are more accurately categorized as rail surface conditions, not internal rail defects, as they do not, in and of themselves, cause service failure of the rail. Although it is not a condition shown to affect the structural integrity of the rail section, it can result in less than desirable dynamic vehicle responses in the higher speed ranges. The flattened rail condition is identified in the table, as well as in the definition portion of §213.113(b), as being three-eighths of an inch or more in depth below the rest of the rail head and 8 inches or more in length. As the defect becomes more severe by a reduced rail head depth, wheel forces increase.

The rule addresses flattened rail in terms of a specified remedial action for those of a certain depth and length. Those locations meeting the depth and length criteria must be limited to an operating speed of 50 mph or the maximum allowable under §213.9 for the class of track concerned, whichever is lower.

“Break out in rail head” is defined as a piece that has physically separated from the parent rail. Rail defects meeting this definition are required to have each operation over the defective rail visually supervised by a person designated under §213.7. Inspectors need to be aware that this definition has applicability across a wide range of rail defects, as indicated in the Remedial Action Table. Where rail defects have not progressed to the point where they meet the definition of a break out, but due to the type, length, and location of the defect, they may present a hazard to continued train operations, inspectors should determine what remedial actions, if any, track owner should institute.

The following are two rail head break out examples where the Note “A” corrective action would be necessary:

Example One: A bolt hole break where the head of the rail is totally separated from the parent rail (either tight or loose), but that piece of rail will not physically lift out of the joint bars by hand. The inspector might determine that the separation was total because the separated piece rattled when tapped. It is important that railroads take the appropriate remedial action in this situation, because it is potentially very unsafe. It is impossible to know what will happen when the next train operates over this defect. That train could cause the piece to become so loose that it comes out of the place, cocks at an angle and causes a wheel to ramp up, derailing the train.

Example Two: A vertical split head defective rail where rail head separation is apparent because the inspector can determine that a physical separation has occurred through the rail head, but the rail head has not entirely separated over the entire length of the defect.

The following is an example where the Note “A” corrective action would not be necessary:

Example: At rail joints, a chipped rail end is not considered a rail defect according to the current § 213.113 table and should not be considered as a breakout in the rail head. Some railroads in the past applied safety “weld straps” to thermite type field welds. These straps do not provide the same support of a joint bar. They would provide only limited support if a weld were to break under a train movement and, as such, they do not comply with the provisions of corrective actions C, D, or E (installation of joint bars).

Figure 54: Weld Strap (Not allowed as corrective action for C, D, or E)

Only a joint bar having full contact with the bottom of the rail head and rail base [see §213.121 (a)] that provides structural support, would comply with corrective actions C, D, or E, of this section so long as the rail has not fractured completely.

Figure 55: Weld Relief Bars (allowed for corrective action C, D, or E, unless the rail has broken)

Once the defective rail breaks, a weld relief bar does not comply with the requirements of §213.121(f), in that they do not adequately support the abutting rail ends. Therefore, these bars would not be an acceptable joint bar for joining two rail ends.

When an FRA inspector finds a rail defect that appears to originate from fatigue at a bond wire attachment weld, the inspector should cite the railroad for 213 defect code 0113B. Inspectors must also identify in their narrative the type of the rail defect (e.g., defective weld, detail fracture, etc.). This defect code is related to placement of bond wire welds on the head of the rail just outside the joint bars, where untempered martensite associated with the welds could lead to fatigue cracking that may rapidly progress to rail failure because of increased stresses.

FRA provides the Track Inspector Rail Defect Reference Manual on the e-library in its Web site. Inspectors are expected to be conversant with rail defect types, appearance, growth, hazards, and methods of detection.

# APPENDIX E WEIGHTS AND MEASURES

## Tie Plates

| Length of Plate (inches) | Width of Plate (inches) | Rail Base (inches) | Weight (lbs.) |
|---|---|---|---|
| 10 | 7-1/2 | 4-7/16 to 5-1/8 | 11.28 |
| 11 | 7-1/2 | 5-1/8 to 5-1/2 | 13.05 |
| 12 | 7-3/4 | 5-3/8 | 16.12 |
| 11 | 7-3/4 | 5-1/2 | 13.56 |
| 12 | 7-3/4 | 5-1/2 | 16.52 |
| 12 | 7-3/4 | 5-1/2 | 16.19 |
| 13 | 7-3/4 | 5-1/2 | 19.89 |
| 14 | 7-3/4 | 5-1/2 | 23.21 |
| 12 | 7-3/4 | 6 | 15.06 |
| 13 | 7-3/4 | 6 | 18.68 |
| 14 | 7-3/4 | 6 | 21.77 |
| 14-3/4 | 7-3/4 | 6 | 23.60 |
| 15 | 7-3/4 | 5-1/2 | 27.58 |
| 16 | 7-3/4 | 6 | 29.89 |
| Pandrol | 7-3/4 | 5-1/2 | 23.5 |
| Pandrol | 7-3/4 | 6 | 24.5 |

## Joint Bars

| Rail Section | Length of Bar (inches) | Weight per Single Bar (lbs.) |
|---|---|---|
| 115/119 RE | 36 | 46.9 |
| 132 and 136/140 RE | 36 | 55.2 |

## Ballast

| | Average Weight per Cubic Foot | | Average Weight per Cubic Yard | |
|---|---|---|---|---|
| Type of Ballast | Loose (lbs.) | Compacted (lbs.) | Loose (lbs.) | Compacted (lbs.) |
| Granite | 88 | 98 | 2,375 | 2,650 |
| Trap Rock | 104 | 114 | 2,800 | 3,075 |

Note: Some variations will be caused by factors such as gradation, moisture, fines, degree of compaction and quarry source.

## Fasteners

| Type | Weight (lbs.) |
|---|---|
| Fast Clips (Bag of 50) | 75 |
| "e" Clips (Bag of 50) | 88 |
| Track Bolts (including Keg) | 210 |
| Track Spikes (including Keg) | 210 |
| Coach Screws (Bag of 100) | 110 |
| 115/119 RE Rail Anchors (Bag of 50) | 125 |
| 136/140 RE Rail Anchors (Bag of 50) | 150 |

## Ties and Timbers

| Type | Size | Weight (lbs.) |
|---|---|---|
| Wood Cross Tie | 6" (6" x 8" x 8'-6")<br>7" (7" x 9" x 8'-6") | 188<br>246 |
| Concrete Cross Tie | 8'-6" | 780 |
| Concrete Switch Tie | 9' to 16' | 105 lbs./ lineal foot |
| Wood Switch Timbers (7" x 9" x Length) | 9<br>10<br>11<br>12<br>13<br>14<br>15<br>16<br>21<br>22 | 260<br>289<br>318<br>347<br>376<br>405<br>434<br>462<br>607<br>636 |

## Rails

| | Calculated Weight Per Yard (lbs.) | Approximate Weight Per 39' (lbs.) |
|---|---|---|
| 115 RE | 114.75 | 4,475 |
| 152 PS | 152.3 | 5,940 |

## Turnout Panels[1]

### Advanced Technology No. 10 with Spring Frog on Concrete Ties

| Panel # | Panel Length (Feet) | Panel Weight (Tons) |
|---|---|---|
| 1 | 43 | 13.0 |
| 2 | 89 | 38.5 |
| Total | 132 | 51.5 |

### Advanced Technology No. 15 on Concrete Ties

| Panel # | Panel Length (Feet) | Panel Weight (Tons) |
|---|---|---|
| 1 | 78 | 27.0 |
| 2 | 52 | 15.5 |
| 3 | 66 | 39.5 |
| Total | 196 | 82.0 |

### Advanced Technology No. 20 on Concrete Ties

| Panel # | Panel Length (Feet) | Panel Weight (Tons) |
|---|---|---|
| 1 | 100 | 32.5 |
| 2 | 77 | 25.0 |
| 3 | 52 | 28.5 |
| 4 | 44 | 18.5 |
| Total | 273 | 104.5 |

### Advanced Technology No. 32-3/4 on Concrete Ties

| Panel # | Panel Length (Feet) | Panel Weight (Tons) |
|---|---|---|
| 1 | 136 | 49.0 |
| 2 | 82 | 27.0 |
| 3 | 80 | 29.5 |
| 4 | 74 | 35.0 |
| 5 | 80 | 33.0 |
| Total | 452 | 173.5 |

### Conventional No. 8 on Wood Ties

| | Panel Length (Feet) | Panel Weight (Tons) |
|---|---|---|
| Nose Panel | 39 | 7.5 |

### Conventional No. 10 on Wood Ties

| | Panel Length (Feet) | Panel Weight (Tons) |
|---|---|---|
| Nose Panel | 39 | 7.5 |

### Conventional No. 15 on Wood Ties

| | Panel Length (Feet) | Panel Weight (Tons) |
|---|---|---|
| Nose Panel | 66 | 11.5 |

### Conventional No. 20 on Wood Ties

| | Panel Length (Feet) | Panel Weight (Tons) |
|---|---|---|
| Nose Panel | 70 | 14.0 |

[1] The total panel length is greater than the constructed length of the turnout because of individual panel overlap.

## Hook Flange Guard Rails

| Length (feet) | Weight (lbs.) |
|---|---|
| 9 | 950 |
| 13 | 1,350 |
| 20 | 2,100 |
| 27 | 2,800 |

## Railbound Manganese Frogs

| | Length | Weight (lbs.) |
|---|---|---|
| No. 8 | 18' | 3,300 |
| No. 10 | 23' | 4,300 |
| No. 15 | 26'-8" | 4,900 |
| No. 20 | 34'-2" | 6,200 |

## Moveable Point Frogs

| | Length | Weight (lbs.) |
|---|---|---|
| No. 15 | 36' | 7,200 |
| No. 20 | 44'-2" | 11,800 |
| No. 32 | 72' | 15,700 |

## Spring Frog

| | Length | Weight (lbs.) |
|---|---|---|
| No. 10 | 39'-10 1/2" | 8,900 |

## Solid Center Slip Frog

| | Length | Weight (lbs.) |
|---|---|---|
| No. 8 | 15' | 3,000 |

## Switch Rails

| Length | Split Switch Point | Weight (lbs.) |
|---|---|---|
| 27'-0" | 16'-6" | 1,250 |
| 38'-0" | 26'-0" | 1,900 |
| 59'-6" | 39'-0" | 2,900 |

## Asymmetrical Switch Points (ZU 1-60 Rail Section)

| | Length | Weight (lbs.) |
|---|---|---|
| No. 15 | 59'-3" | 2,900 |
| No. 20 | 81'-4 1/2" | 3,950 |
| No. 32-3/4 | 121'-4 1/2 | 5,950 |

## Crossings - Track

| | Approximate Weight (lbs.) |
|---|---|
| High Angle Crossing (Ties Not Included) | 14,000 |
| Low Angle Crossing (Ties Not Included) | 18,000 |

[1] The weights given are average weights. The weight of a rail crossing is controlled by the type and angle of crossing.

## Slips

| Type | Panel Weight (tons) |
|---|---|
| #8 Double Slip with Solid Center Frogs and with Ties | 44 |
| #10 Double Slip with Moveable Center Points and with Ties | 39 |

| Slip Component | Weight (lbs.) |
|---|---|
| Knuckle Rail Assembly (with Easer Rail) | 2,500 |

## Decimals of an Inch for Each 32nd of an Inch

| Fraction | Decimal |
|---|---|
| 1/32 | .03125 |
| 1/16 | .0625 |
| 3/32 | .09375 |
| 1/8 | .125 |
| 5/32 | .15625 |
| 3/16 | .1875 |
| 7/32 | .21875 |
| 1/4 | .250 |
| 9/32 | .28125 |
| 5/16 | .3125 |
| 11/32 | .34375 |
| 3/8 | .375 |
| 13/32 | .40625 |
| 7/16 | .4375 |
| 15/32 | .46875 |
| 1/2 | .500 |
| 17/32 | .53125 |
| 9/16 | .5625 |
| 19/32 | .59375 |
| 5/8 | .625 |
| 21/32 | .65625 |
| 11/16 | .6875 |
| 23/32 | .71875 |
| 3/4 | .750 |
| 25/32 | .78125 |
| 13/16 | .8125 |
| 27/32 | .84375 |
| 7/8 | .875 |
| 29/32 | .90625 |
| 15/16 | .9375 |
| 31/32 | .96875 |
| 1 | 1.000 |

| Fractions of an Inch | DECIMALS OF A FOOT FOR EACH 32ND OF AN INCH | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0"** | **1"** | **2"** | **3"** | **4"** | **5"** | **6"** | **7"** | **8"** | **9"** | **10"** | **11"** |
| 0 | .0000 | .0833 | .1667 | .2500 | .3333 | .4167 | .5000 | .5833 | .6667 | .7500 | .8333 | .9167 |
| 1/32 | .0026 | .0859 | .1693 | .2526 | .3359 | .4193 | .5026 | .5859 | .6693 | .7526 | .8359 | .9193 |
| 1/16 | .0052 | .0885 | .1719 | .2552 | .3385 | .4219 | .5052 | .5885 | .6719 | .7552 | .8385 | .9219 |
| 3/32 | .0078 | .0911 | .1745 | .2578 | .3411 | .4245 | .5078 | .5911 | .6745 | .7578 | .8411 | .9245 |
| 1/8 | .0104 | .0938 | .1771 | .2604 | .3438 | .4271 | .5104 | .5938 | .6771 | .7604 | .8438 | .9271 |
| 5/32 | .0130 | .0964 | .1797 | .2630 | .3464 | .4297 | .5130 | .5964 | .6797 | .7630 | .8464 | .9297 |
| 3/16 | .0156 | .0990 | .1823 | .2656 | .3490 | .4323 | .5156 | .5990 | .6823 | .7656 | .8490 | .9323 |
| 7/32 | .0182 | .1016 | .1849 | .2682 | .3516 | .4349 | .5182 | .6016 | .6849 | .7682 | .8516 | .9349 |
| 1/4 | .0208 | .1042 | .1875 | .2708 | .3542 | .4375 | .5208 | .6042 | .6875 | .7708 | .8542 | .9375 |
| 9/32 | .0234 | .1068 | .1901 | .2734 | .3568 | .4401 | .5234 | .6068 | .6901 | .7734 | .8568 | .9401 |
| 5/16 | .0260 | .1094 | .1927 | .2760 | .3594 | .4427 | .5260 | .6094 | .6927 | .7760 | .8594 | .9427 |
| 11/32 | .0286 | .1120 | .1953 | .2786 | .3620 | .4453 | .5286 | .6120 | .6953 | .7786 | .8620 | .9453 |
| 3/8 | .0313 | .1146 | .1979 | .2813 | .3646 | .4479 | .5313 | .6146 | .6979 | .7813 | .8646 | .9479 |
| 13/32 | .0339 | .1172 | .2005 | .2839 | .3672 | .4505 | .5339 | .6172 | .7005 | .7839 | .8672 | .9505 |
| 7/16 | .0365 | .1198 | .2031 | .2865 | .3698 | .4531 | .5365 | .6198 | .7031 | .7865 | .8698 | .9531 |
| 15/32 | .0391 | .1224 | .2057 | .2891 | .3724 | .4557 | .5391 | .6224 | .7057 | .7891 | .8724 | .9557 |
| 1/2 | .0417 | .1250 | .2083 | .2917 | .3750 | .4583 | .5417 | .6250 | .7083 | .7917 | .8750 | .9583 |
| 17/32 | .0443 | .1276 | .2109 | .2943 | .3776 | .4609 | .5443 | .6276 | .7109 | .7943 | .8776 | .9609 |
| 9/16 | .0469 | .1302 | .2135 | .2969 | .3802 | .4635 | .5469 | .6302 | .7135 | .7969 | .8802 | .9635 |
| 19/32 | .0495 | .1328 | .2161 | .2995 | .3828 | .4661 | .5495 | .6328 | .7161 | .7995 | .8828 | .9661 |
| 5/8 | .0521 | .1354 | .2188 | .3021 | .3854 | .4688 | .5521 | .6354 | .7188 | .8021 | .8854 | .9688 |
| 21/32 | .0547 | .1380 | .2214 | .3047 | .3880 | .4714 | .5547 | .6380 | .7214 | .8047 | .8880 | .9714 |
| 11/16 | .0573 | .1406 | .2240 | .3073 | .3906 | .4740 | .5573 | .6406 | .7240 | .8073 | .8906 | .9740 |
| 23/32 | .0599 | .1432 | .2266 | .3099 | .3932 | .4766 | .5599 | .6432 | .7266 | .8099 | .8932 | .9766 |
| 3/4 | .0625 | .1458 | .2292 | .3125 | .3958 | .4792 | .5625 | .6458 | .7292 | .8125 | .8958 | .9792 |
| 25/32 | .0651 | .1484 | .2318 | .3151 | .3984 | .4818 | .5651 | .6484 | .7318 | .8151 | .8984 | .9818 |
| 13/16 | .0677 | .1510 | .2344 | .3177 | .4010 | .4844 | .5677 | .6510 | .7344 | .8177 | .9010 | .9844 |
| 27/32 | .0703 | .1536 | .2370 | .3203 | .4036 | .4870 | .5703 | .6536 | .7370 | .8203 | .9036 | .9870 |
| 7/8 | .0729 | .1563 | .2396 | .3229 | .4063 | .4896 | .5729 | .6563 | .7396 | .8229 | .9063 | .9896 |
| 29/32 | .0755 | .1589 | .2422 | .3255 | .4089 | .4922 | .5755 | .6589 | .7422 | .8255 | .9089 | .9922 |
| 15/16 | .0781 | .1615 | .2448 | .3281 | .4115 | .4948 | .5781 | .6615 | .7448 | .8281 | .9115 | .9948 |
| 31/32 | .0807 | .1641 | .2474 | .3307 | .4141 | .4974 | .5807 | .6641 | .7474 | .8307 | .9141 | .9974 |

# APPENDIX F SPECIAL TRACKWORK EXAMPLES

**Figure 1:**
**Advanced Technology Turnout**

**Figure 2:**
**No. 8 Double Slip with Solid Center Frogs**

**Figure 3:**
**No. 10 Double Slip with Moveable Center Points**

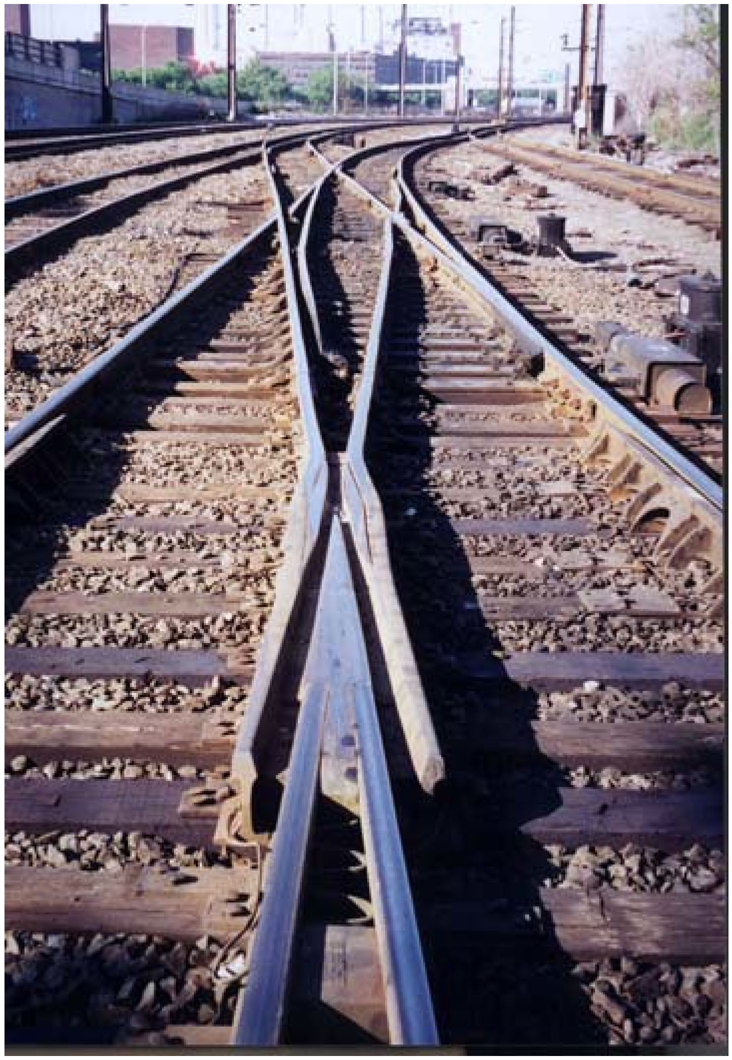

**Figure 4:**
**No. 10 Single Slip with Moveable Center Points**

**Figure 5:**
**Moveable Center Point Assembly for a Double Slip**

**Figure 6:**
**Solid Center Slip Frog**

**Figure 7:**
**Bolted Rail Crossing 3 Rail Design - High Angle**

**Figure 8:**
**Manganese Steel Insert Crossing - High Angle**

**Figure 9:**
**Manganese Steel Insert Crossing - Low Angle**

**Figure 10:**
**Solid Manganese Crossing - Medium Angle**

**Figure 11:**
**Crossing – One Way Low Speed (OWLS)**

**Figure 12:**
**Flange Bearing Frog**

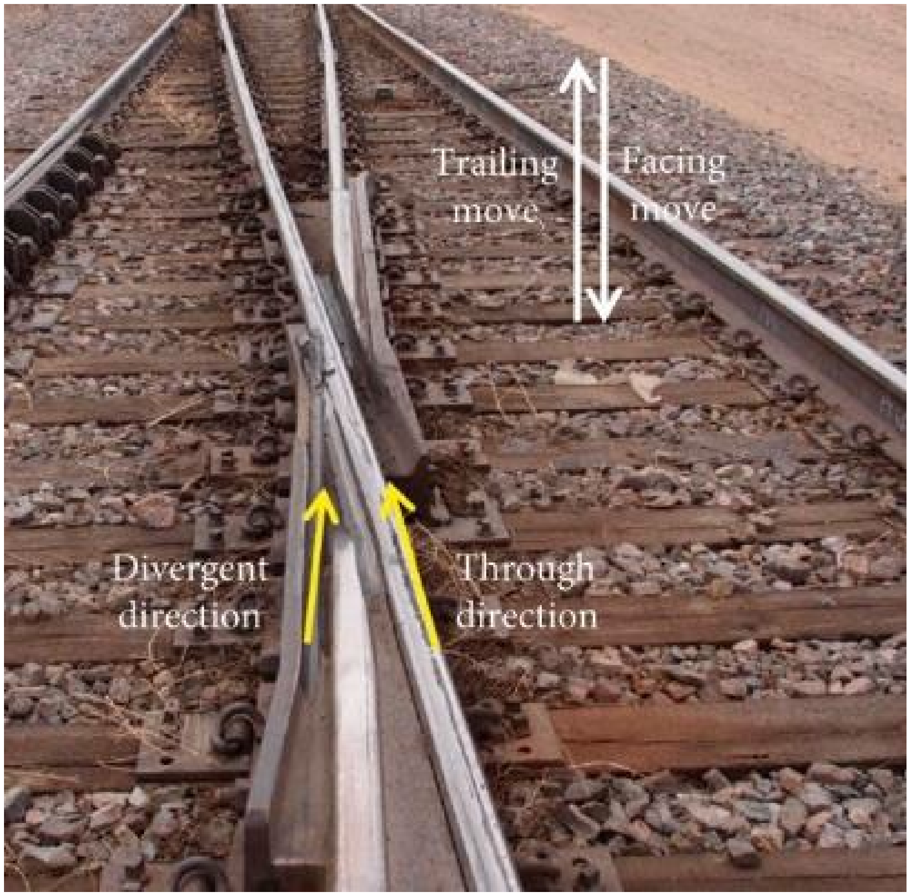


**Figure 13:**
**Structure of Flange Bearing Frog**

**Figure 14:**
**MJS Rod for Slips**

**Figure 15:**
**O'Brien Rod for Slips**

**Figure 15:**
**Bumping Post with Sliding Shoes**


**Figure 16:**
**Bumping Post with Hydraulic Ram**

**Table 1: Standard Turnouts**

| Turnout Description | Turnout Classification | Standard Track Plan |
|---|---|---|
| **Conventional Turnouts** | | |
| No. 8 welded[1][4] turnout with RBM (wood ties) | 8 RBM | AM 73184 |
| No. 10 welded turnout[4] with RBM (wood ties) | 10 RBM | AM 73185 |
| No. 15 welded turnout with RBM (wood ties) | 15 RBM | AM 73186 |
| No. 20 welded turnout with RBM (wood ties) | 20 RBM | AM 73187 |
| **Advanced Technology Turnouts** | | |
| No. 10 welded turnout with spring frog (concrete ties) | 10 SF | AM 73241 |
| No. 15 tangential turnout with moveable point frog and asymmetrical switch points (concrete ties) | T 15 MPF | AM 73230 |
| No. 20 tangential turnout with moveable point frog and asymmetrical switch points (concrete ties) | T 20 MPF | AM 73220 |
| No. 26.5 tangential turnout with straight moveable point frog and asymmetrical switch points (concrete ties)[2] | T 26.5 SMPF | AM 73210 |
| No. 26.5 tangential turnout with curved moveable point frog and asymmetrical switch points (concrete ties)[3] | T 26.5 CMPF | NOT AN AMTRAK STANDARD |
| No. 32.75 tangential turnout with straight moveable point frog and asymmetrical switch points (concrete ties) | T 32.75 SMPF | AM 73200 |

(1) A turnout with a floating heel block is designated as a "welded turnout."
(2) Preferred over curved moveable point frog design.
(3) These turnouts are located at Swift and Secaucus Transfer.
(4) No. 8 and 10 self-guarded turnouts also exist but are not a preferred design. They are only to be used under specific restricting conditions where an RBM frog with guard rails cannot fit.

(a) Plans for turnouts given in the above table are provided in the Standard Track Plan Book

(b) Turnouts shall be inspected and maintained in accordance with the guidelines contained in Parts I and II of the MW 1000.

A list of the major standard types of turnouts currently in service on the Amtrak system along with general turnout information is given in the following table.

**Table 2: General Characteristics of Standard Turnouts**

| General Characteristics of Standard Turnouts[b], [c] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Turnout Classification[g]** | **Ties** | **Switch Point Length (ft.) [a]** | **Switch Angle** | **Switch Rail Length (ft.)** | **Frog Number** | **Frog Length (ft.)** | **Lead Length (ft.) [e]** | **Frog Angle** | **Frog Type** | **Standard Track Plan[d] Number** |
| **CONVENTIONAL TURNOUTS** | | | | | | | | | | |
| 8 RBM | Wood | 16′-6″ | 1°-48'-32" | 27′-0″ | 8 | 18′-0″ | 68′-0″ | 7º 09′ 10″ | RBM | AM 73184 |
| 10 RBM | Wood | 16′-6″ (h) | 1°-48'-32" | 27′-0″ | 10 | 23′-0″ | 77′-4¾″ | 5º 43′ 29″ | RBM | AM 73185 |
| 15 RBM | Wood | 26′-0″ (h) | 0°-44'-47" | 38′-0″ | 15 | 26′-8″ | 111′-2¾″ | 3º 49′ 06″ | RBM | AM 73186 |
| 20 RBM | Wood | 39′-0″ (h) | 0°-25'-32" | 59′-6″ | 20 | 34′-2″ | 154′-6½″ | 2º 51′ 51″ | RBM | AM 73187 |
| **ADVANCED TECHNOLOGY TURNOUTS** | | | | | | | | | | |
| 10 SF | Concrete | 16′-6″ | 1°-48'-32" | 27′-0″ | 10 | 39′-10½″ | 77′-4 ¾″ | 5º 43′ 29″ | SF | AM 73241 |
| T 15 MPF | Concrete | 45'-4 1/2" | 0°-15'-27" | 59′-3″ | 15 | 36′-0″ | 122′-6 5/16″ | 3º 49′ 06″ | MPF | AM 73230 |
| T 20 MPF | Concrete | 55'-4 1/2" | 0°-04'-26.5" | 81′-4 ½″ | 20 | 44′-2″ | 170′-3 5/8″ | 2º 51′ 51″ | MPF | AM 73220 |
| T 26.5 CMPF | Concrete | 95'-4 1/2" | 0°-03'-01" | 113′-6″ | 26.5 | 76′-0″ | 276′-4 3/8″ | 2º 09′ 39.9″ | CMPF | NON-STANDARD |
| T 32.75 SMPF | Concrete | 85'-4 1/2" | 0°-03'-00" | 121′-4 ½″ | 32.75 | 72′-0″ | 299′-8 13/16" | 1º 44′ 52.4″ | SMPF | AM 73200 |

Notes:

(a) Switch point length is the length from point of switch to the heel block or point of fixation.
(b) Early concrete tie designs use vapé screw and plastic inserts to secure switch and frog plates.
(c) Standard concrete tie designs use the cast-in-shoulder to secure switch plates and frog plates.
(d) See Track Supervisor or Division office for latest revision of Standard Track Plans.
(e) For tangential geometry turnouts with moveable point frogs the lead length is measured to the theoretical point of frog (TPF).
(f) Footnote removed.
(g) Turnout Classifications: RBM = railbound manganese; T = tangential; SF = spring frog; MPF - moveable point frog; SMPF = straight moveable point frog; CMPF = curved moveable point frog
(h) There may be a few conditions that warrant the use of a concrete tie conventional turnout. Examples would be where concrete ties exist on both ends of the turnout and there is not enough room for a tangential turnout or a tangential turnout would not be practical because of low track speeds.
(i) The use of the T 26.5 SMPF turnout is limited as cab signaling for 60 MPH diverting moves requires a special cab code which may not be compatible with all carriers operating through the turnout. Complete compatibility is required before this turnout can be used. This design is preferred over the curved moveable point frog design.

**Table 3: General Characteristics of Standard Slips**

| Slip No. | End Frog to End Frog (1/2" points) | Radius | Outside Switch Point Length | Center Switch Point Length | Switch Angle | Frog Angle | End Frog No. | End Frog Length | Center Frog Length |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 76'-1 3/4" | 678.5' | 20'-3 7/16" | N/A | 1°-46'-22" | 7°-09'-10" | 8 | 18'-0" | 15' |
| 9 | 85'-7 1/2" | 1204.9' | 22'-6" | N/A | 1°-20'-15" | 6°-21'-35" | 9 | 20'-11/16" | 15' |
| 10 | 95'-1 3/8" | 1135.5'/ 1222.3' | 20'-0" | 14'-3 3/16" | 1°-10'-00" | 5°-43'-29" | 10 | 23'-0" | N/A |
| 15 | 142'-7" | 2009.2'/ 3390.8' | 30'-0" | 11'-5 11/16" | 0°-41'-00" | 3°-49'-06" | 15 | 33'-0" | N/A |

Notes: Data may not be consistent with all existing slips.