

RTD MAINTENANCE OF WAY

TRACK SAFETY STANDARDS



RTD



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2021



This document establishes a standard for the periodic inspection and maintenance of fixed-structure rail transit tracks. This includes periodic visual, electrical and mechanical inspections of components that affect safe and reliable operation. This standard also identifies the necessary qualifications for RTD MOW employees or contractors who perform periodic inspection and maintenance tasks.

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Intended Audience

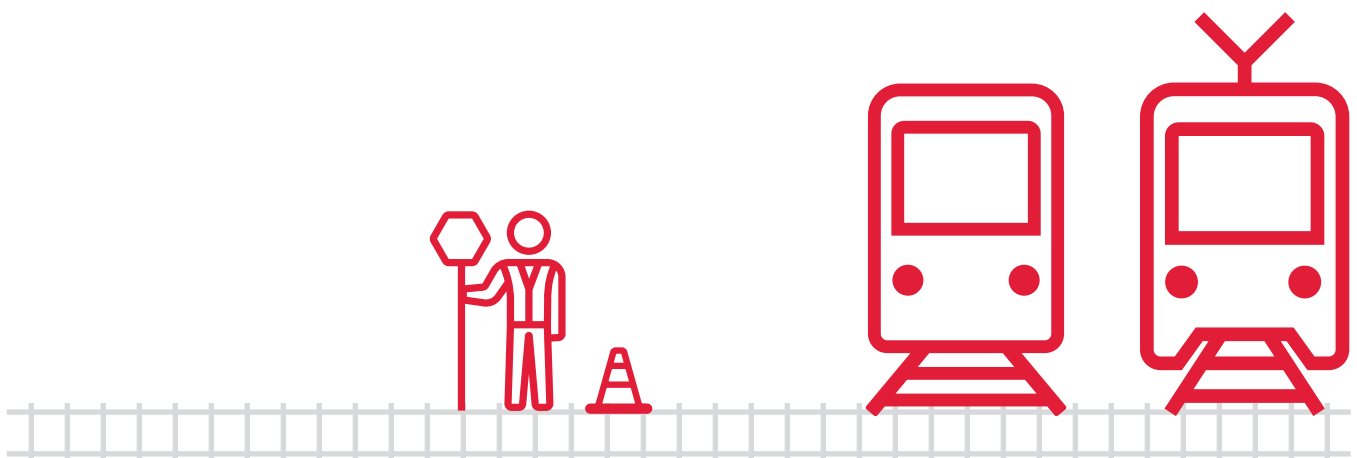
This document is intended for use by RTD Light Rail Maintenance-of-Way (MOW). This is not to be confused with RTD commuter rail (north metro), DTP / DTO, or Eagle projects. This is due to differences in regulator oversight, where Light Rail is regulated by the FTA, DORA, PUC, FRA, and Internal Safety ISR and commuter rail is regulated solely by the FRA. When reporting to work each day, employees must consult the bulletin board, train orders, or refer to the Hub. If any employee is unaware of specific posted instructions, a supervisor or dispatcher should be contacted immediately.

Introduction

RTD MOW rail transit safety standards represent an industry consensus on safety practices for RTD MOWs (RTS) to help achieve a high level of safety for passengers, employees and the general public. This document was created with its provisions, namely RTD MOWs (operating agencies), original equipment manufacturers (OEMs), consultants, engineers and general interest groups. This standard provides procedures for inspecting and maintaining rail transit tracks.

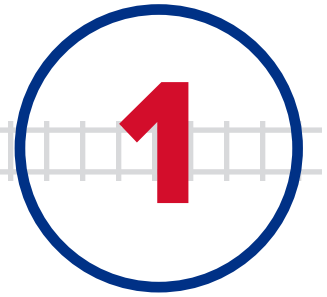
This standard intends to meet the following objectives:

- To ensure special life/safety equipment is operational and reliable
- To help incorporate safety considerations during the inspection and maintenance process
- To identify inspection criteria and maintenance standards that provide a high level of passenger and personnel safety



Rail Transit Track Inspection and Maintenance





1. Overview

1.1 Measuring track not under load

When unloaded track is measured to determine compliance with the requirements of this standard, the amount of rail movement, if any, that occurs while the track is loaded must be added to the measurement of the unloaded track.

1.3 Restoration and renewal of track

When any work is performed on the track to repair or correct conditions described herein, the work is to be under the supervision of a qualified person as designated by Section 2.

1.2 Combination of conditions

Requirements as prescribed in this part are described as single conditions at a given location. When a combination of conditions at a given location exists, but none individually requires action, a qualified person (as designated in Section 2) must evaluate the condition for protection and take appropriate action. Train dynamics, track geometry and track design, location of the track, maximum speeds over the area, and any other factors that could negatively influence the severity of the conditions found must be taken into consideration when evaluating the proper action(s) to be taken, particularly in special work and curved locations.

2. Qualified Persons

2.1 Designation of qualified persons

RTD MOW shall designate qualified persons to supervise track maintenance, track renewal and inspection of track under traffic. Those designated persons shall meet the requirements described herein.

2.2 Work performed by others

Work performed by contractors or other non-agency parties on the RTD MOW's track shall be inspected by a qualified person, as described herein, prior to placing the track in service.

2.3 Minimum qualifications of qualified persons

A person designated by the RTD MOW as a qualified person shall:

- a) Have at least:
 - One year of satisfactory related experience inspecting, constructing or maintaining track and special work; and/or
 - a combination of experience in track maintenance and training from a qualified course in track inspection or from a college-level educational program related to track inspection; or
 - have demonstrated enough knowledge or have had satisfactory supervisory experience on another transit or railroad system; and
- b) Demonstrate to the RTD MOW that he or she:
 - knows and understands the requirements of these standards;
 - can detect deviations from these requirements; and
 - can prescribe appropriate remedial action to correct or safely compensate for those deviations.

3. Inspection

A list of qualified persons shall be maintained by the RTD MOW.

3.1 Track inspection

- a) Tracks used by revenue trains shall be inspected twice weekly by riding over the track in a vehicle at a speed that allows detection of noncompliance with these standards. In the unusual event that a walking or riding inspection cannot be performed, a qualified person must inspect the track from a revenue vehicle in a position that allows full view of the roadbed. Inspections must be performed by a qualified person as prescribed by Section 2. An interval of at least two but not more than 11 calendar days must elapse between inspections.
- b) Non-revenue and yard tracks shall be inspected once a quarter.
- c) Walking inspection of the mainline shall take place once a quarter.

Components of a section of track shall be inspected and their condition recorded on an inspection form, with all deviations or deficiencies recorded on the form. Remedial action for defects must be taken in accordance with the parameters set forth in this standard and as prescribed in Section 2 and Section 5. All forms shall be submitted daily to a supervisor for review, and

electronic copy filed in the enterprise asset management system (EAM). All forms shall be complete and retained on file in the EAM system after the date of inspection. Refer to Appendix E for samples of track and switch inspection forms.

3.2 Rail inspection

Ultrasonic rail flaw detection of mainline tracks shall be performed at least once per year. Defective rails shall be clearly marked on each side of the rail web and base. Inspection records shall show the nature of defects, location of flaw and action taken. If rail defects are found during walking track inspections, use the standards listed in the rail defect remedial action chart to determine appropriate action. Broken rails must be reported using a standard form (a sample form is shown in Appendix E). Records shall be maintained for a minimum of two years after inspection and one-year after remedial action.



3.3 Continuous welded rail inspection

Special inspections of continuous welded rail (CWR) shall occur when the ambient temperature causes the rail temperature to meet or exceed the neutral temperature of the rail. Particular attention is to be given to periods of temperature fluctuations, looking for signs of high thermal stresses in the rails. If daily cycles of extreme temperature fluctuations occur, consideration shall be given to repeated inspections. Defects found shall be recorded on a track inspection form and filed in EAM. See Section B.6 of Appendix B.

3.4 Geometry inspection

The geometry of mainline standard gage track shall be inspected and recorded at least once per year by an automated track inspection or measurement vehicle; this inspection will supplement the weekly visual inspection of track. Data collected in accordance with Section 8, “Track geometry,” shall be maintained for three years. Defects detected shall be given to the maintenance manager for corrective action. Defects shall be reported as prescribed in Section 4. This requirement is not applicable to embedded track; see Section 13 for inspection requirements for embedded or street-running track.

3.5 Detailed switch and crossing inspection

- a) Mainline switches, track crossings and moveable bridge lift rails shall be inspected for defects monthly.
- b) Yard switches shall be inspected for defects every three months.
- c) Mainline and yard track switches that are signaled or electrically controlled shall be inspected jointly by signal and track forces annually. Annual switch inspection forms shall be used, and all information shall be completed for each switch inspected. The completed form shall be forwarded to the respective maintenance managers and kept on file for a minimum of one year from the date of inspection.
- d) Inspection after track-related failure. Switches that failed to operate properly due to a track cause or an undetermined cause shall be inspected by both signal - and track-qualified inspectors to determine the cause and to ensure that the repair is complete.

3.6 Special inspection

In the event of fire, flood, severe storm or other occurrence that might have damaged the track and/or structure, a special inspection of the affected track and structure must be made as soon as possible after the occurrence.

Defects reported by the public and employees shall be investigated as soon as possible. Appropriate corrective action shall be taken.

4. Condition reporting

The RTD MOW has specific procedures for reporting defects and/or conditions, corrective action and/or mitigating measures to be taken when track conditions found by qualified personnel deviate from the standards shown herein. A speed-based track classification system shall be used based on class of track. Operations over deficient track conditions shall not be allowed to exceed the prescribed minimum safety requirements indicated herein. The RTD MOW will follow the requirements prescribed in Section 3, 'Inspection', regarding the retention of records concerning the inspections performed.

4.1 Reporting of a condition's location

Proper reporting of the location of exceptions is a necessary part of the information flow to management and others involved with follow-up and repair of conditions. When reporting a defect, all information, including track number, line stationing or other unique repeatable methodology as determined by the RTD MOW must be utilized.

4.2 Classes of track

The speed-based track classification system shall conform to the following:

- a) The track classes shall be as described in **Table 1**.
- b) Maintenance criteria shall be established using the same speed-based track classification system.



TABLE 1
Classes of Track

Class¹	Maximum allowable train speed²
1	15 mph
2	30 mph
3	55 mph

1. Over track that meets all the other requirements prescribed herein.
2. The designated operating speeds of some transit systems may be determined by designed automatic train control systems or through established operating practices. The agency may alter the maximum allowable train speeds in this table to match its established train speeds if so required, provided that:
 - a. the maximum allowable operating speeds shown herein to describe a class of track shall not be exceeded; and
 - b. The deviations from the minimum standards shown herein are not exceeded for the specified operating speeds.

4.3 Condition prioritization

Shall conform to the following and used for input in EAM:

- a) The condition prioritization system shall be as described in **Table 2**; and
- b) Any RTD MOW employee that knows or has notice that the track does not comply with the standards shown herein shall report the condition using this hierarchy and take the required corrective action.

TABLE 2
Condition Prioritization

Priority	Description
1	The qualified person(s) detecting such condition shall make every effort to correct the condition immediately and must also evaluate whether to allow operations to continue under supervision, or to place the track out of service immediately. If operation is allowed to continue, then the person(s) making the decision must not leave the scene until relieved or until the defect is repaired. When “walking” trains over such a condition, each train shall be stopped short of the defect and the person on the ground shall communicate the situation to the train operator. Movements shall be made at restricted speed with extreme caution; that is, proceeding no faster than 15 mph; prepared to stop at least two car lengths short of a visible object on the roadway; ready to make a fast stop; watching rails and switches for the route; and looking for anything on the roadbed that is unsafe to pass.
2	Conditions that require inspection by a qualified person within 24 hours of the time of the detection of the condition. The investigating person shall immediately determine whether a slow speed order is necessary and what work is required and shall base these decisions on findings and other factors, such as the type of defect, the location and permanent speed of the track in question. Every effort shall be made to correct these defects as soon as practicable.
3	Such designation alerts to a track condition that affects the ride comfort qualities of the track and that may degrade to a worse condition if left uncorrected. Work programs shall be established for the correction of these defects.
4	Conditions that do not require any immediate action. These conditions may affect ride comfort qualities of the track should they degrade to a worse condition. Uncorrected defects shall be recorded, and the reports shall be used for scheduling future work.

NOTE: The RTD MOW may modify the above prioritization code to meet its individual requirements; however, modifications shall be consistent with the above table and uniformly applied throughout the RTD MOW’s maintenance standards.

5. Corrective action

This section describes the methods and systems that the RTD MOW shall apply when it knows, or has notice, that the track does not comply with the requirements specified herein.

5.1 Required action

Any RTD MOW employee that knows, or has notice, that the track does not comply with the requirements specified herein shall:

- a) bring the track into compliance; or
- b) to operate under conditions that do not meet class 1, or over priority 1 conditions, put train movements under the continuous supervision of a qualified person, subject to conditions set forth herein, at an appropriate restrictive speed not to exceed 15 mph; or
- c) stop operations over that track.

5.2 Conditions detected by automated track inspection vehicles

Conditions detected by automated track inspection vehicles shall be classified according to the designations in **Table 2**. A qualified person shall perform the analysis and interpretation of those conditions within 48 hours of the inspection, as well as any determination regarding the required corrective action. Such determination shall be made by taking into account the type of defect, its location, the type of track, the permanent speed of the track in the area and any other combination of geometry conditions that could negatively influence the severity of the conditions found. In any case, if a qualified person discovers that the condition is an exception to these standards, then the prescribed action(s) shall be taken.



6

6. Roadbed

This section prescribes minimum requirements for the roadbed and areas immediately adjacent to the track structure.

6.1 Drainage

Drainage is of the utmost importance in the maintenance of track. Each drain, cross-drain or other water-carrying facility under or immediately adjacent to the transit property's track must be kept free of debris and obstructions to accommodate expected water flow. Water must not be allowed to accumulate or stand around or on track and third rail (power rail) components.

6.1.1 High-water conditions

High-water conditions in track shall restrict train operations as shown in **Table 3**.

TABLE 3
High-Water Conditions¹

Class of Track	Priority	Operating Speed	High-Water Condition
1	1	15 mph or less	Within the head of either running rail ²
2	2	16 to 30 mph	Above the base of either running rail
3	3	31 to 55 mph	Up to the base of either rail

1. This table is not applicable for street-running track work. RTD MOWs with street-running track shall develop and adhere to specific guidelines for their conditions.
2. Only supervised operation is permitted where water is above the running surface of either rail.



6.2 Vegetation

Vegetation found in the ballast area indicates fouled ballast and resulting poor drainage. Vegetation that is within or immediately adjacent to the roadbed must be controlled so that it does not:

1. become a fire hazard;
2. obstruct visibility of signs, highway rail crossings and signals;
3. interfere with employees performing normal trackside duties;
4. prevent proper functioning of signal and communication lines;
5. prevent employees from visually inspecting moving equipment from their normal duty stations; or
6. strike or rub the sides or tops of trains.

6.3 Storage of materials and equipment along the right-of-way

Material and equipment stored along the trackway shall be placed where it will not interfere with the safe operation of trains. Placement shall be secure so that vibration from passing trains will not allow materials or equipment to move into the rail vehicles'

clearance envelope. In addition, material and equipment stored shall be placed such that it will not:

1. interfere with possible evacuation of passengers and personnel in an emergency;
2. interfere with possible actions of emergency personnel;
3. come in contact with rail vehicles;
4. interfere with operation of train control systems;
5. interfere with operation of switches and special track work;
6. interfere with operation of moveable bridges;
7. interfere with traction power distribution systems; or
8. contact the running or guardrails.

In addition, extra precaution shall be taken with items such as rail, pipe, conduit and inner ducts to allow for thermal expansion and contraction.

Proper housekeeping practices shall be maintained in all work areas at all times. This includes the removal of material or equipment when work has been completed in the area.



7. Track appliances and devices

This section prescribes minimum requirements for certain track appliances and devices.

7.1 Derails

Each derail must be clearly visible. Switch point derails shall be maintained as per Section 11 of this standard; for other types of derails, the manufacturer's recommendations shall be followed. When in a locked position, a derail shall be free of lost motion that would prevent it from performing its intended function. Each derail should be properly installed for the rail to which it is applied

7.3 Switch heaters

The operation of a switch heater must not interfere with the proper operation of the switch or otherwise jeopardize the safety of equipment.

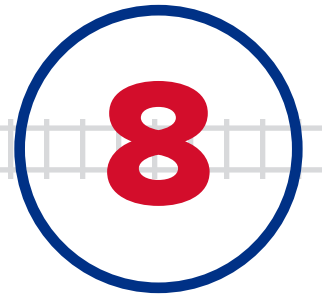
7.2 Slip rails (expansion joints)

Particular attention shall be given to slip rails or expansion joints. Any unusual longitudinal or vertical movement must be noted. All the appropriate requirements of Section 10 of this standard shall be met and slip rails should be inspected monthly. The sliding joint must be inspected for any loose bolts, loose hold-down devices (spikes, screws, elastic fasteners, etc.). The sliding rail shall be checked to ensure that it has been properly lubricated and is indeed moving, and the distance between the end of the free rail and the cast stop on the sliding joint must be checked to ensure that it is within tolerance.



7.4 Rail lubrication

- a) Rail lubrication shall be used to reduce rail wear and for noise abatement purposes. Additionally, rail lubrication can help the train's wheels to negotiate sharp curves by decreasing the friction between the wheel flange and the side of the running rail and guardrail (restraining rail).
- b) High-pressure, mechanical or other approved type of lubricators shall be used.
- c) Rail lubricators shall be installed at the following locations:
 - On all sharp curves as determined by the RTD MOW. The initial applicator shall be placed ahead of the curve, prior to entering the body of the curve, at a point such that the lubricant is carried effectively throughout the curve. Additional applicators shall be placed along the curve as required.
 - Other locations deemed necessary, according to field conditions. Locations may be adjusted considering rail wear rates and train operating conditions.
- d) A suitable enclosure shall be provided to house the lubricating equipment and controls as well as the lubricant.
- e) Lubrication equipment shall be thoroughly inspected by trained personnel according to an approved schedule. All equipment in service is to be tested at least twice a year, especially during extreme weather changes and after any repairs or adjustments have been performed. During inspections, adjustments shall be made as required based on the conditions observed.
- f) Rail lubricators shall be maintained and adjusted to provide the proper amount of lubricant at all times. Excessive accumulation of lubricant at the applicators or at any other points along the track shall be avoided; the lubricant must be distributed as uniformly and evenly as possible throughout the curve. Lack of lubrication results in high rates of wear of rails and wheels, as well as an increase of friction between the flanges of the wheel and the rail, and therefore shall be avoided. The pressure shall be adjusted as required to provide the required amount of lubricant flow as determined by an inspection of the rails along the curve. If during inspection of the lubricators any conditions (such as excessive accumulation of lubricant on the rails) are found that may interfere with the safe operation of trains over the area, corrective action shall be immediately performed, and the pressure adjusted accordingly.
- g) The material used for lubrication shall conform to the specifications of the RTD MOW. In addition, the manufacturer's recommendations regarding use, storage and handling of the product shall be followed. Lubricant sampling shall be performed at least once a year to ensure that the product does meet the required properties.



8. Track geometry

This section prescribes the requirements for gage, horizontal alignment, surface and superelevation of track.

8.1 Track gage

8.1.2 Gage limits

8.1.1 Gage

Track gage is measured at right angles to the rail, $\frac{5}{8}$ in. below the plane of the top of the rails. Refer to Note 1 of **Table 4**.

Track gage shall be maintained within the limits prescribed in **Table 4**.

TABLE 4
Track Gage Limits¹

Class of Track	Priority	Operating Speed	Deviation from 56 1/2 ^{4,2}	
			Minimum ³	Maximum ⁴
1	1	15 mph or less	-1/2 in.	+1 1/2 in.
2 and 3	2	16 to 60 mph	-1/2 in.	+1 1/4 in.

1. This table is intended for RTD MOWs using American Association of Railroads (AAR) standard wheels, regardless of the design track gage. If nonstandard wheels are used, then the agency shall perform a special evaluation of its specific conditions and set appropriate limits, in accordance with the documents listed in the section under References.
2. Where gage varies by design, for example because of sharp horizontal curvature or to reduce truck hunting on tangent, then that designed gage shall be used to determine the allowable deviations specified above. These adjustments to track gage shall be clearly designated in the RTD MOW's standards.
3. No operation is permitted when loaded gage deviation is less than -1/2 in.
4. No operation is permitted when loaded gage deviation is more than +1 1/2 in.



8.2 Horizontal alignment (line)

Horizontal alignment standards for curved and tangent track are based on the mid-ordinate (mid-chord offset) of a fixed chord length. Measurements shall be taken at points on the gage side of the railhead. On tangent track, both rails shall be considered; the rail with the worst alignment shall be used for the application of these standards. On curves, the outside rail shall be used. The deviation from uniformity of the mid-offset from either a 62 ft. or 31 ft. chord shall conform to that shown in **Table 5**.

TABLE 5
Maximum Allowable Horizontal Alignment Deviation

Class of Track	Priority	Operating Speed	Maximum Allowable Deviation from Design Value			
			Tangent Track		Curved Track	
			31 ft. Chord	62 ft. Chord	31 ft. Chord	62 ft. Chord
1	1	15 mph or less	3 in.	5 in.	3 in.	5 in.
2	2	16 to 30 mph	2 ½ in.	3 in.	2½ in.	3 in.
3	2	31 to 60 mph	1¼ in.	1¾ in.	1¼ in.	1¾ in.

8.3 Track surface

RTD MOWs shall maintain the surface of their track within the limits prescribed in **Table 6**. For RTD MOWs with speeds enforced by train control systems, see Appendix A for corresponding track surface deviation limits.

8.4 Superelevation

Curved track shall be superelevated in accordance with each RTD MOW's standards and maintained within the limits described in **Table 6**.



8.5 Superelevation runoff

Superelevation runoff shall be at a uniform rate, within the limits of track surface deviation prescribed in **Table 6**. Superelevation runoff shall extend the full length of the spirals. If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, then part of the runoff may be on an adjacent tangent or curve. If the superelevation is run off within the curve, then the minimum superelevation in the curve shall be used to calculate the maximum operating speed. If the superelevation is run off in an adjacent tangent, then the maximum cross level on tangent track shall not exceed that shown in **Table 6**.



TABLE 6
Track Surface

Class of Track:		1	2	3
Priority:		1	2	3
Operating Speed:		15 mph or less	16 to 30 mph	31 to 55 mph
Condition description	Chord length or distance ¹			
Runoff in any 31 ft. of rail at the end of a raise may not be more than	31 ft.	3½ in.	3 in.	2 in.
Deviation from uniform profile	31 ft. chords	1½ in.	1¾ in.	1⅛ in.
	62 ft. chords	3 in.	2¾ in.	2¼ in.
Deviation from constant cross level	See note ²	3 in.	2 in.	1¾ in.
Deviation from desired elevation in spirals	See note ²	2 in.	1¾ in.	1½ in.
Difference in constant cross level between two points	31 ft.	2 in.	1¾ in.	1½ in.
	62 ft.	3 in.	2¼ in.	2 in.
Variation in cross level in spirals between two points	31 ft.	2 in.	1¾ in.	1¼ in.
	62 ft.	3 in.	2¼ in.	2 in.

1. Either a 31 ft. or 62 ft. chord length or distance may be designated to be used. However, the same chord length shall be exclusively used when applying this table.
2. The chord length or distance shall be chosen to be representative of the maximum twist tolerances allowed by the RTD MOW's vehicles exhibiting the largest degree of stiffness to twist conditions.

8.6 Determination of superelevation

The method(s) used by the RTD MOW to determine maximum operating speeds on curves shall be maintained on file.

8.7 Horizontal curve data

Each RTD MOW shall maintain horizontal curve data for every mainline curve on its system. The data shall include the location, overall length, radii or degree of curve, superelevation, length of super elevation runoff, spiral length and maximum allowable operating speed. This data shall be readily accessible to all personnel designated as qualified herein.

This section prescribes minimum requirements for ballast, crossties and rail fasteners.



9. Track structure

9.1 Ballast

Unless it is otherwise structurally supported, all tracks shall be supported by material that will:

- a) transmit and distribute the load of the track and rolling equipment to the subgrade without overloading the subgrade;
- b) restrain the track laterally, longitudinally and vertically under dynamic loads imposed by rolling equipment and thermal stress exerted by the rails;
- c) provide adequate drainage for the track; and
- d) maintain proper track cross level, surface and alignment.

Clean, well compacted ballast must be located in the cribs around the ends of all ties at a depth equal to not less than two-thirds the height of the tie. All cribs should be filled to within 1 in. of the base of the rail. The ballast height at the center of the tie cribs (away from the running rails) may be below these limits at the discretion of the track engineer. If the top of the ballast reaches a level lower than the halfway point of the ties (for more than five cribs in a row), then a slow order should be placed on the track and speeds reduced to one-half

maximum authorized speed. In any 20 ft. of ballasted track, at least 80 percent of all cribs should be filled to within 1 in. of the top of the tie.

In ballasted track with Continuous Welded Rail (CWR), the minimum ballast shoulder width shall be 12 inches, and 10 inches for conventional jointed ballasted track (other than special work). If the ballast shoulder is less than the above specified limits, refer to **Table 7** below for the condition and operating speed restriction.

When track has been disturbed, such as due to maintenance activities, the track must be examined. If the track does not conform to the requirements outlined in this section, then the maximum authorized speed must be reduced as defined herein, until a proper section has been restored.

Ballast must be kept from touching the rails after compaction. A space of at least 1 in. between the ballast and the base of the rail must be maintained to provide clearance between the rail and the ballast.



Ditches, pipes, catch basins, culverts and bridge openings must be kept free of obstructions. Ditches must be kept clear of grass and weeds. All drainage facilities must be checked and cleaned (as necessary) immediately after storms.

For concrete ties with center-to-center spacing of 2 ft. or more, the depth of ballast under the tie must be a minimum of 12 in. For wood or composite ties with center to center spacing of 19.5 in., the depth of ballast under the tie must be a minimum of 9 in.

See **Table 7** and **Table 8**.



TABLE 7
Ballast Guidelines for Wood & Engineered Composite Ties

Crib Ballast (below the top of the tie)	Priority Condition	Speed
3 to 6 in.	3	40 mph
Greater than 6 in.	2*	15 mph
Ballast Shoulder Width**		
8 to 10 in.	3*	40 mph
Less than 8 in.	2*	15 mph
Number of Tie Ends Exposed in 20 ft.		
3 to 5	3	40 mph
More than 5	2	15 mph

* Additional ballast should be scheduled for installation

** The minimum shoulder width for track with wood or engineered composite ties shall be 10 inches

TABLE 8
Ballast Guidelines for Concrete Ties

Crib Ballast (below the top of the tie)	Priority Condition	Speed
2 to 5 in.	3	40 mph
Greater than 5 in.	2*	15 mph
Ballast Shoulder Width**		
6 to 10 in.	3*	40 mph
Less than 6 in.	2*	15 mph
Number of Tie Ends Exposed in 20 ft.		
3 to 5 in.	3	40 mph
More than 5 in.	2	15 mph

* Additional ballast should be scheduled for installation

** The minimum shoulder width for track with concrete ties shall be 12 inches



9.2 Rail fastener requirements

9.2.1 General

- a) Rail fasteners (crossties, direct fixation and other rail fasteners) shall be made of a material to which rail can be securely fastened. Fasteners must be capable of holding rails to their proper gage and alignment, preventing excessive horizontal and vertical movement and transmitting the wheel loads to the supporting structure or ballast.
- b) Each segment of track shall have a sufficient number of rail fasteners that in combination provide effective support that will maintain gage, surface and alignment as prescribed herein.
- c) The minimum number of non-defective rail fasteners (along a single rail) for any 39 ft. length of rail shall be as prescribed in Table 9.
- d) The number of consecutive ineffective rail fasteners shall not be more than that prescribed in Table 10.



TABLE 9

Minimum Number of Non-Defective Rail Fasteners for Any 39 ft. Length of Rail

Class of Track	Operating Speed	Priority	Minimum Effective for Any 39 ft. of Rail
1	< 15 mph	1	6
2 and 3	16 to 60 mph	2	8

TABLE 10

Maximum Number of Consecutive Defective Rail Fasteners Per 39 ft. Length of Rail

Class of Track	Operating Speed	Priority	Tangent and Curves with Radii at or Over 2000 ft.	Curves with Radii Between 1000 and 2000 ft.	Curves with Radii of Less Than 1000 ft.
1 and 2	< 30 mph	1	5	4	3
3	31 to 60 mph	2	4	3	2

9.2.2 Timber or engineered composite crossties

Timber or engineered composite crossties shall be considered ineffective if any of the following conditions exist:

- a) There are fewer than two spikes along each rail (one on the gage side and one on the field side of each rail), except in cases of special tie plates designed otherwise;
- b) The crosstie is broken through;
- c) The crosstie is spike-killed to the extent that it can no longer effectively hold spikes;
- d) The crosstie is split or impaired to the extent that the tie will allow the ballast to work through;

- e) The crosstie is plate-cut more than 1 in.;
- f) The crosstie has deteriorated such that the tie plate or base of rail can move laterally more than ½ in. relative to the crosstie.

9.2.3 Concrete ties

Concrete ties shall be considered ineffective if any of the following conditions exist:

- a) The rail clip assembly is broken, missing or impaired.
- b) A rail clip bolt is stripped or broken.
- c) The rail clip shoulder on the tie is damaged such that it provides no lateral support to the clips.



- d) The tie is severely cracked or broken.
- e) Surface spalls, chips or broken-out areas expose the pre-stressed reinforcing wire in the concrete tie.
- f) The tie has a longitudinal crack running through a vertical plane that affects its structural integrity.
- g) A concrete tie has a crack in the rail base area that is large enough to be easily seen.
- g) Any fastener component is bent, cracked or broken.
- h) The rail hold-down is defective or missing so that the gage cannot be maintained.

9.2.4 Direct fixation fasteners

Direct fixation fasteners shall be considered ineffective if any of the following conditions exist:

- a) The rail clip is broken.
- b) Two anchor bolts are missing, broken or so loose as to be rendered ineffective on one pad.
- c) Two anchor bolt inserts are stripped or otherwise unusable on one pad.
- d) The pad is corroded, deteriorated or broken such that the rail fasteners or anchor bolts no longer provide lateral or vertical support.
- e) The concrete supporting the fastener is deteriorated or impaired such that it does not provide proper support.
- f) The elastomer is poor or separated from any of its components or has bulged appreciably from beneath a bearing washer.
- a) Ties under rail joints must be adequately tamped to reduce pumping and ensure proper support.
- b) The center tie and one of the shoulder ties under a supported joint should be non-defective. Both ties under a suspended joint should be non-defective.
- c) If the center tie in a supported joint is defective (and two shoulder ties are non-defective), or if one tie is defective in a suspended joint, then speed should be reduced to 25 mph.
- d) If two of three ties in a supported joint or both ties in a suspended joint are defective, then speed should be reduced to 10 mph.
- e) Each rail joint, in tracks having a maximum speed of 30 mph, should be supported by at least one crosstie whose centerline is within 48 in. of the rail end.
- f) In tracks having designed speed greater than 30 mph up to 90 mph, joints should be supported by at least one crosstie whose centerline is within 36 in. of the rail end, or two crossties whose centerlines are within 24 in. of either side of each rail joint location.

9.2.5 Joint ties



9.2.6 Tie plates

- a) In track where timber cross ties are in use, there must be tie plates under the running rails on at least eight of any 10 consecutive ties.
- b) No metal object that causes a concentrated load by solely supporting a rail should be allowed between the base of the rail and the bearing surface of the tie plate.
- c) In station areas, care must be taken to maintain the alignment, cross level and surface of the track along the platforms in such a way to ensure compliance with ADA regulations and the RTD MOW's gap and step standards.

9.3 Clearances

- a) Track clearances shall be maintained as required by the car and line equipment clearance diagrams. Any indication of equipment striking wayside objects requires prompt action. Any violation to personnel clearances must be promptly communicated to the responsible manager and marking of the affected area shall be performed as soon as possible. Clearances must be checked after any work has been completed on, or in the vicinity of, the tracks.
- b) Before performing horizontal or track alignment changes, the responsible manager must ensure that a physical inspection of the area to be surfaced is conducted prior to the beginning of the work. Special attention must be paid to reductions in overhead or lateral clearances caused by the installation of conduits, pipes, cables, light fixtures or any other appurtenances. Clearance measurements shall be made before any work has begun. Measurements of clearances before and after the work is completed must be recorded and kept on file in the manager's office.

10. Rail

This section prescribes the requirements for the maintenance of rail.

10.1 Defective rails

This section prescribes the actions required when defective rails are discovered.

10.1.1 Knowledge of defective rails

RTD MOWs employees that know or have notice that a rail in track contains any of the defects listed in Table 11 shall immediately have a qualified person determine whether or not the track may continue in use unless the rail is replaced or the appropriate remedial actions described in **Table 11a**, **Table 11b** and **Table 11c** are taken.

10.1.2 Application of joint bars on defective rails

Where appropriate, when applying joint bars to mitigate rail defects, the following actions shall be taken:

- a) Bolts shall be applied to the defective rail through the outermost holes.
- b) The minimum number of bolts that would be used for a rail joint at that same location as prescribed herein shall be used.
- c) Care shall be taken not to drill bolt holes through the rail at the location of the defect.
- d) At welds, if joint bars are used to protect rail defects, then precautions shall be taken to ensure that the joint bars properly fit the rail. Either special rail joint bars specifically designed for that rail section for use at weld locations, or grinding the weld upset metal, shall be used. Field-modified, torch-cut or strap protective bars shall not be used.
- e) If a rail defect is found in the wing or heel rails of a frog, then the existence of two frog bolts on both sides of the defect may be considered the same as joint bars.



10.1.3 Defects within switch points and stock rails

If a rail defect is found within a switch point or stock rail adjacent to a switch point, then, at a minimum, the following action shall be taken, unless more restrictive action is required by **Table 11a, Table 11b or Table 11c**:

- a) Where remedial actions C, D or E given in the notes for Table 11c require the use of joint bars, and joint bars cannot be placed due to the physical configuration of the switch, then remedial action B will govern, provided that there are reinforcing bars on both sides of the switch point and that there are at least two bolts or rivets on each side of the defect; or
- b) A qualified person shall supervise each train movement over defective rail; and
- c) The operating speed over defect location is limited as determined by a qualified person.

10.1.4 Definition of rail defects

RTD MOWs shall use the definitions of defects shown herein.

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.

Compound fissure means a progressive fracture originating in a horizontal split head, which turns up or down in the head of the rail as a smooth, bright or dark surface progressing until substantially at a right angle to the length of the rail. Compound fissures require examination of both faces of the fracture to locate the horizontal split head from which they originate.

Horizontal split head means a horizontal progressive defect originating inside the rail head, usually $\frac{1}{4}$ in. 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.

Vertical split head means a vertical split through or near the middle of the head, and 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.

Split web means a lengthwise crack along the side of the web and extending into or through it.

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.

Broken base means any break in the base of the rail.

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 that have internal origins. Detail fractures may arise from shelly spots, head checks or flaking.



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.

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 paragraph are found.

Damaged rail means any rail broken or injured by wrecks; broken, flat or unbalanced wheels; slipping; or similar causes.

Flattened rail means a short length of rail, not a joint, that has flattened out across the width of the rail head to a depth of $\frac{3}{8}$ in. or more below the rest of the rail. 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 length is relatively short, as compared with a condition such as head flow on the low rail of curves.

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 should be reported as separate defects.

Defective weld means a field or plant weld containing any discontinuities or pockets, exceeding 5 percent of the rail head area individually or 10 percent 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, entrapment of slag or sand, under bead 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.

Head and web separation means a progressive fracture, longitudinally separating the head from the web of the rail at the head fillet area.

“Shelly Spots” or “Squats” means a condition where a thin (usually $\frac{3}{8}$ inch in depth or less) shell-like piece of surface metal becomes separated from the parent metal in the rail head, generally at the gauge corner. It may be evidenced by a black spot appearing on the rail head over the zone of separation or a piece of metal breaking out completely, leaving a shallow cavity in the rail head. In the case of a small shell there may be no surface evidence, the existence of the shell being apparent only after the rail is broken off or sectioned. Shelling normally occurs on the upper gauge face of the rail head, extending longitudinally; shells originate under the surface of the rail head. Shelling occurs from high contact stresses from wheel-rail interaction, especially when severe non-conformal wheel-rail contact occurs. Shell propagation can develop into a transverse defect (TD); most often, they are not visible on the rail surface until they reach advance stages of development. The



horizontal component of the shell can mask the detection of the transverse component of the defect that leads to a detail fracture.

“Head Checks” means hair-line cracks which appear in the gauge corner of the rail head, at any angle with the length of the rail. When not readily visible, the presence of the checks may often be detected by the raspy feeling of their sharp edges. Head checks are a result of cold working of the metal surface due to the interaction between the wheels and the rail, usually at the gauge corner; this is also referred to as a form of rolling contact fatigue (RCF). Head checks can progress into more severe rail surface conditions such as the initiation point for detail fractures or compound defects. Severe head checking can also interfere with the detection of internal rail defects.

“Flaking” means small shallow flakes of surface metal generally not more than 1/4 inch in length or width, that break off the gauge corner of the rail head. Flaking takes place only on the running surface of the rail, usually near its gauge corner, and it is not as deep as shelling. Flaking is the result of surface metal friction, flow and plastic deformation, caused by concentrated wheel loads, resulting in severe compressive shear deformation of the rail surface. This surface condition can progress in depth and could also become the origin point for detail fractures; severe flaking can also interfere with the detection of internal rail defects.

“Spalling” means cracking and chipping of the rail head surface, usually at the top of the head of the rail. It is usually caused by high horizontal wheel-rail creeping forces, transverse frictional forces and extreme wheel-rail contact stresses resulting in

micro-cracking and head chipping. Spalling can interfere with the detection of internal rail defects.

“Corrugation” means cyclic, “wave-like” irregularities in the running surface of the rails, identified by an uneven wear pattern. Short wave corrugations have a wavelength of 1 to 3 inches, and a depth of less than 10 thousandths of an inch, and more prevalent to be found in transit and light rail systems.

10.1.5 Definition of transverse defect size

RTD MOWs may either use percent of cross-sectional area or a size designation for determining appropriate remedial action on transverse defects as shown in **Table 11a**, as follows:

- a) Only one designation shall be used.
- b) That same designation shall be exclusively used and uniformly applied system wide.
- c) That same designation shall be identified in that RTD MOW’s standards.

10.1.6 Torch-cut rails

Torch-cut rail ends shall be used in an emergency only. Torch-cut rails must be replaced as soon as possible and protected with a slow speed order under supervision until replaced.



10.1.7 Base-corroded rails

Rail corrosion consists of the deterioration and disintegration of the rail steel starting at its surface, due to chemical reactions, oxidation and electrolysis effects in the presence of water containing salts or other impurities. It is therefore paramount to divert any water away from the track elements (rails, fasteners and ties) so that they are not affected by electrolysis and corrosion. In addition, rail corrosion could lead to rail breaks and signal system failures. Levels of rail corrosion shall be classified as follows:

Medium (moderate): Heavy rusting and flaking of rail surfaces; surface pitting is medium-sized (approximately $\frac{1}{8}$ in. in diameter on average) and more prevalent; loss of any section of the rail at the web or base is small (less than $\frac{1}{4}$ in.); small cracks, if present, on the deteriorated surfaces are less than $\frac{1}{8}$ in. in length.

Severe (significant): Surface pitting is large-sized (more than $\frac{1}{8}$ in. on average) and extensive; rail base or web have loss of section equal to or larger than $\frac{1}{4}$ in., either on a uniform basis or concentrated at point or points on the base; cracks in the deteriorated surfaces, if present, are $\frac{1}{8}$ in. or larger in length.

Base-corroded rails must be inspected and verified by a track supervisor. The base-corroded rails shall be marked with highly visible paint in the web of the rail only, so that they can be easily monitored. The supervisor shall inspect all base-corroded rails in the section.

Replacement of base-corroded rails shall be scheduled as follows:

- a) In general, severely based corroded rails shall be replaced within no more than 90. of their detection, or immediately if there are any cracks of any size at the location where the corrosion is most severe. If the severely base-corroded rail cannot be replaced within 48 hrs. then either joint bars, carryover bars and/or nonconductive plates shall be installed at the location of the most severe corrosion, or the rail shall be cut and joint bars installed if there are any cracks at that location.
- b) Base-corroded rails of medium severity shall be replaced based on project availability.
- c) If there are any Priority 2 visual or track geometry defects present at locations where rails of medium or severe base corrosion do exist, then immediate action shall be taken, consisting of placement of a slow speed order, immediate replacement of the corroded rail and correction of the Priority 2 defect.

10.1.8 Required action

RTD MOWs shall either replace rail or, at a minimum, perform the actions shown in **Table 11a**, **Table 11b** or **Table 11c**.

TABLE 11a
Rail Defect Remedial Action

Type of Transverse Rail Defect	Railhead Cross-Sectional Area Weakened by Defect		Priority	Minimum Remedial Action ¹
	Greater Than	Less Than		
Transverse fissure	5%	70%	2	B
	70%	100%	1	A2
	100%	—	1	A
Compound fissure	5%	70%	2	B
	70%	100%	2	A2
	100%	—	1	A
Detail fracture	5%	70%	2	B
	70%	100%	2	A2
	100%	—	1	A
Engine burn fracture	5%	70%	2	B
	70%	100%	2	A2
	100%	—	1	A
Defective weld	5%	25%	3	C
	25%	80%	2	D
	80%	100%	1	A2 or both E and H
	100%	—	1	A or both E and H



TABLE 11b
Rail Defect Remedial Action

Type of Longitudinal Rail Defect	Longer Than	Shorter Than	Priority	Minimum Remedial Action ¹
Horizontal split head	1 inch	2 inches	3	H and F
	2 inches	4 inches	2	I and G
	4 in.	—	1	B
	Breakout in railhead	1	A	
Vertical split head	1 inch	2 inches	3	H and F
	2 inches	4 inches	2	I and G
	4 inches	—	1	B
	Breakout in railhead	1	A	
Split web	1 inch	2 inches	3	H and F
	2 inches	4 inches	2	I and G
	4 inches	—	1	B
	Breakout	1	A	
Piped rail	1 inch	2 inches	3	H and F
	2 inches	4 inches	2	I and G
	4 inches	—	1	B
	Breakout	1	A	
Head web separation	1 inch	2 inches	3	H and F
	2 inches	4 inches	2	I and G
	4 inches	—	1	B
	Breakout	1	A	
Bolt hole crack	½ inch	1 inch	3	H and F
	1 inch	1½ inches	2	H and G
	1½ inches	—	1	B
	Breakout	1	A	
Broken base	1 inch	6 inches	2	D
	6 inches	—	1	A or both E and I



TABLE 11c
Rail Defect Remedial Action

Other Rail Defects	Depth	Size	Priority	Minimum Remedial Action ¹
Flattened rail	Greater than or equal to 3/8 in.	Greater than or equal to 8 in.	2	H
Ordinary break	n/a	Any	1	A or E
Damaged rail	n/a	Any	2	D
Base-corroded rail	Medium (moderate)		2	A2; see section 10.1.7
	Severe (significant)		1	Replace rail; see section 10.1.7
Short wave rail corrugation	Over 1/8 inch deep		2	Grind rail
Wheel burn, "squat" or shell	Less than 1/8 inch	Less than 3 inches	2	A2
	Equal to or larger than 1/8 inch	Equal to or larger than 3 inches	1	Replace rail

1. Minimum remedial actions are coded as follows:

- A A qualified person shall supervise each operation over defective rail at a speed not to exceed 15 mph.
- A2 A qualified person shall make visual inspection. The qualified person may determine that operation may continue without continuous visual supervision at a maximum of 10 mph for up to 24 hours. If the rail is not replaced within that 24-hour period, then inspections by a qualified person shall continue, not more than 24 hours apart, until the rail is replaced or a determination is made requiring a more restrictive action.
- B Apply joint bars within 20 days after it is determined to keep the track in use and limit operating speed over defective rail to a maximum of 30 mph until joint bars are applied; thereafter, limit speed to 60 mph. When a search for internal rail defects is conducted and defects are discovered in tracks with operating speed over 60 mph, then the operating speed shall be limited to 60 mph for a period not to exceed four days. If the defective rail has not been removed from the track or a permanent repair made within four days of the discovery, then the maximum operating speed shall be limited to 30 mph until joint bars are applied; thereafter, limit speed to 60 mph.
- C Apply joint bars within 10 days after it is determined by a qualified person to keep the track in use. In tracks with operating speed over 60 mph, limit operating speed over the defective rail to 30 mph or less as authorized by a qualified person, until joint bars are applied; thereafter, limit speed to 60 mph.
- D Apply joint bars to defect within 10 days if determined to keep the track in use with a maximum operation speed of 30 mph or less as authorized by a qualified person. After joint bars are applied, limit speed to 60 mph or less as authorized by a qualified person.
- E Apply joint bars.
- F Qualified person to re-inspect rail within three months after it is determined to keep the track in use. G Qualified person to re-inspect rail within one month after it is determined to keep the track in use.
- H than 60 mph or less as determined by a qualified person.
- I Limit operating speed over defective rail to no more than 30 mph or less as determined by a qualified person.
- J Limit operating speed over defective rail as determined by a qualified person.



10.2 Rail wear

Rail wear limits are established by RTD MOW based on rail section and wheel flange dimension. A recommended practice for 115RE rail with standard AAR wheels is provided in Appendix C as a guide.

10.2.1 Measuring rail wear

Rail gage face wear and head width shall be measured at the gage line as defined herein. Vertical wear shall be measured along the centerline of the rail web.

10.3 Rail joints and rail ends

Rail joints, joint bars applied to rail defects, and joint bars on restraining rails shall be maintained as described herein. Joint bar area condition is a function of the condition of the joint bars, bolts, insulation (for insulated joints) and the rail itself. The visual inspection of the joint bar area shall include a thorough examination of the condition of the area, detecting loose or missing bolts, and loose joint bar assemblies, as well as rail end defects.

10.3.1 Rail joints

- a) Each rail joint insulated joint and compromise joint shall be of a structurally sound design and dimensions for the rail on which it is applied.
- b) If a joint bar on Classes 3 track is cracked, broken, or because of wear allows excessive vertical movement of

either rail when all bolts are tight, then it shall be replaced.

- c) If a joint bar is cracked or broken between the middle two bolt holes, then all operations over that joint must be supervised and the bars scheduled for immediate replacement.
- d) In the case of conventional jointed track, each rail shall be bolted with at least two bolts at each joint in Classes 2 through 3 track and with at least one bolt in Class 1 track.
- e) In the case of continuous welded rail track, each rail shall be bolted with at least two bolts in each rail at each joint.
- f) Each joint bar shall be held in position by four track bolts tightened to allow the joint bar to firmly support the abutting rail ends and to allow longitudinal movement of the rail in the joint to accommodate expansion and contraction due to temperature variations. When no-slip, joint-to-rail contact exists by design, the requirements of this paragraph do not apply.
- g) No rail shall have a bolt hole that is torch cut or burned in Classes 2 through 3 tracks.
- h) No joint bar shall be reconfigured by torch cutting in Classes 2 through 3 tracks.
- i) If bolts are broken or missing, then the following actions should be taken:
 - If less than two bolts per rail: reduce speed to 10 mph.
 - One bolt per rail: rail gap greater than 1 inch: supervise all operations.
 - For one bolt at one rail end and a rail gap greater than 3 in.: suspend operations.



- j) Joint bars should fit so that they are vertical within the fishing area of the rail. A bar that is cocked causes a point stress to be introduced into the rail head, which can result in a crack forming in the head web fillet, or a broken joint bar.
- k) The use of four-hole bars is acceptable only in bolted rail territory (six-hole bars are required in CWR track or where CWR joins bolted rail track) as long as the bolt heads alternate sides. Unless the joint is to be welded.
- l) Joint slotting (cross-grinding) must be performed on all rail ends before chipping of the rail occurs. Particular attention should be paid to insulated joints so that corrective actions can be taken to prevent signal failure due to rail end lipping or defective insulation.

10.3.2 Rail joint and weld stagger

Bolted joints, bonded joints, insulated joints and field welds must meet the following minimum stagger distances:

- 10 ft., 0 in., to opposite rail joints or field welds;
- 14 ft., 0 in., to joints or field welds on the same rail.

10.3.3 Rail ends

Rail ends shall be maintained as described herein. Rail end condition is defined in terms of the depth of the defect, or lateral and vertical straightness as measured over a 36 in. length. This definition is used for both battered joints and battered welds.

10.3.3.1 Rail end mismatch

Gage face mismatch shall be measured at the gage line as described herein. Tread mismatch shall be measured along the centerline of the rail web. Rail end mismatch shall not exceed that shown in **Table 12**.



TABLE 12
Rail End Mismatch

Class of Track	Operating Speed	Priority	Tread Mismatch	Gage Face Mismatch
1	Less than 15 mph	1	¼ in.	¼ in.
2	16 to 30 mph	2	¼ in.	⅜ in.
3	31 to 55 mph	3	⅜ in.	⅜ in.

10.3.3.2 Rail end batter

Rail end batter (including battered welds) shall not exceed that shown in **Table 13**.

TABLE 13
Rail End Batter

Class of Track	Operating Speed	Priority	Tread Mismatch
1	Less than 15 mph	1	½ in.
2	16 to 30 mph	2	¼ in.
3	31 to 55 mph	3	⅜ in.



10.4 Continuous welded rail (CWR)

10.4.1 Procedures

RTD MOW's CWR policy has in effect and complies with written procedures that address the installation, adjustment, maintenance and inspection of CWR, and a training program for the application of those procedures. Each plan shall include, at a minimum, those shown herein.

- a) Procedures for the installation of CWR that include:
- Designation of a desired rail installation temperature range for the geographic area in which the CWR is located; in general, CWR should be laid when the rail temperature is within the temperature range specified by the following equations:
$$DRT_{\text{MIN}} = ([2Ht + Lt] / 3) + 10$$
$$DRT_{\text{MAX}} = (([2Ht + Lt] / 3) + 25) \pm 5,$$
where:
 DRT_{MIN} = minimum desired rail temperature, degrees Fahrenheit
 DRT_{MAX} = maximum desired rail temperature, degrees Fahrenheit
Ht = highest recorded rail temperature, degrees Fahrenheit
Lt = lowest recorded rail temperature, degrees Fahrenheit
 - De-stressing procedures/methods, which address proper attainment of the desired rail installation temperature range when adjusting CWR.

- b) Rail anchoring or fastening requirements that will provide sufficient restraint

to limit longitudinal rail and fastener movement to the extent practical. These requirements shall specifically address CWR rail anchoring or fastening patterns on bridges, bridge approaches and at other locations where possible longitudinal rail and fastener movement associated with normally expected train-induced forces is restricted.

- c) CWR joint installation and maintenance procedures that require that:
- Each rail shall be bolted with at least two bolts at each CWR joint.
 - In the case of a bolted joint installed during CWR installation, the RTD MOW shall either, within 60 days:
 - weld the joint;
 - install a joint with six bolts; or
 - anchor every tie 195 ft. in both directions from the joint; and
 - In the case of a bolted joint in CWR experiencing service failure or a failed bar with a rail gap present, the RTS shall either:
 - weld the joint;
 - replace the broken bar(s), replace the broken bolts, adjust the anchors and, within 30 days, weld the joint;
 - replace the broken bar(s), replace the broken bolts, install one additional bolt per rail end, and adjust anchors;
 - replace the broken bar(s), replace the broken bolts, and anchor every tie 195 ft. in both directions from the CWR joint; or
 - replace the broken bar(s), replace the broken bolts, add rail with provisions for later adjustment as per



the requirements of this section, and reapply the anchors.

d) Procedures shall specifically address maintaining a desired rail installation temperature range when cutting CWR, including rail repairs, in-track welding and in conjunction with adjustments made in the area of tight track, a track buckle or a pull-apart. Rail repair practices shall take into consideration existing rail temperature so that:

- when rail is removed, the length installed shall be determined by taking into consideration the existing rail temperature and the desired rail installation temperature range; and
- under no circumstances should rail be added when the rail temperature is below that designated in paragraph a) herein, without provisions for later adjustment.


e) Procedures that address the monitoring of CWR in curved track for inward shifts of alignment toward the center of the curve as a result of disturbed track.

f) Procedures that control train speed on CWR track during maintenance work, track rehabilitation, track construction or any other event that disturbs the roadbed or ballast section and reduces the lateral or longitudinal resistance of the track, and when the difference between the average rail temperature and the average rail neutral temperature is in a range that causes buckling-prone conditions to be present at a specific location. In formulating the procedures under this paragraph, the RTD MOW shall:

- determine the speed required, and the duration and subsequent removal of any speed restriction based on the restoration of the ballast, along with sufficient ballast reconsolidation to stabilize the track to a level that can accommodate expected train-induced forces (ballast reconsolidation can be achieved through either the passage of train tonnage or mechanical stabilization procedures, or both); and
- take into consideration the type of fasteners and crossies used.

g) Procedures shall prescribe when physical track inspections are to be performed to detect buckling-prone conditions in CWR track. At a minimum, these procedures shall address inspecting track to identify:

- locations where tight or kinked rail conditions are likely to occur;
- locations where track work of the nature described in Appendix B.4.3 has recently been performed;
- pull-apart prone conditions in CWR track, including locations where pull-apart or stripped- joint rail conditions are likely to occur, and
- in formulating the procedures under this paragraph, the RTD MOW shall:
 - specify the timing of the inspection; and
 - specify the appropriate remedial actions to be taken when buckling-prone conditions are found.



h) Procedures that prescribe the scheduling and conduct of inspections to detect cracks and other indications of potential failures in CWR joints. In formulating the procedures under this paragraph, the RTD MOW shall:

- Address the inspection of joints and the track structure at joints, including, at a minimum, periodic on-foot inspections.
- Identify joint bars with visible or otherwise detectable cracks and conduct remedial action as indicated in the CWR Remedial Action Table shown in Appendix B.
- Specify the conditions of actual or potential joint failure for which personnel must inspect, including, at a minimum, the following items:
 - loose, bent or missing joint bolts;
 - rail end batter or mismatch that contributes to instability of the joint; and
 - evidence of excessive longitudinal rail movement in or near the joint, including but not limited to wide rail gap, defective joint bolts, disturbed ballast, surface deviations, gap between tie plates and rail, or displaced rail anchors.
- Specify the procedures for the inspection of CWR joints that are imbedded in highway-rail crossings or in other structures that prevent a complete inspection of the joint, including procedures for the removal from the joint of loose material or other temporary material.

- Specify the appropriate corrective actions to be taken when personnel find conditions of actual or potential joint failure, including on-foot follow-up inspections to monitor conditions of potential joint failure in any period prior to completion of repairs.
 - Specify the timing of the inspections, which should be based on the configuration and condition of the joint. At a minimum, the RTD MOW should specify that all joints in CWR track be inspected annually.
 - All CWR joints that are located in switches, turnouts, track crossings, lift. rail assemblies or other transition devices on moveable bridges must be inspected on foot at least monthly, consistent with these requirements.
 - The RTD MOW may include in its switches, turnouts, track crossings, and lift. rail assemblies inspections, in lieu of the joint inspections required in this section, CWR joints that are located in track structure that is adjacent to switches and turnouts, provided that the RTD MOW precisely defines the parameters of that arrangement in the CWR plans.
- i) RTD MOWs shall have in effect a comprehensive training program for the application of these written CWR procedures, with provisions for periodic retraining for those individuals designated as qualified herein.
- j) RTD MOWs shall prescribe record-keeping requirements necessary to provide an adequate history of track constructed with CWR. At a minimum, these records must include the following:



- Rail temperature, location and date of CWR installations or adjustments. This record shall be retained for at least one year.
- A record of any CWR installation or maintenance work that does not conform to the written procedures. Such record shall include the location of the rail and be maintained until the CWR is brought into conformance with such procedures.

10.4.2 Inspection of CWR

When inspecting CWR, the following areas shall be addressed:

- a) Adequacy of the ballast section at curved track, sags, culverts, ballasted deck bridges and locations where vehicles may have been driven along the right-of-way or where footpaths may cross tracks.
- b) Loose, bent or broken bolts. Anchor position should be checked, and anchors repositioned against the ties if necessary.
- c) Evidence of rail moving through fastenings/anchors.
- d) Evidence of track moving downhill or with the direction of traffic by noting if anchored ties are moving toward non-anchored ties.
- e) Short flat spots in curve alignment or line kinks in tangent track and determine if ties are floating in the ballast section by digging out one tie end at a time. All ties in welded rail track must be properly tamped.

- f) Evidence of the base of rail not seated uniformly on the tie plates. Overstressed rail will have a tendency to lift, and tilt on the tie plates.

10.4.3 Maintaining and working CWR track

Before performing track work that has the potential to disturb CWR track, a qualified person must determine if the rail needs to be de-stressed or other appropriate actions taken to maintain the stability of the track. See Appendix B for further discussion of track work that constitutes disturbed track and CWR maintenance practices.

11. Restraining (guard) rails on regular track

This section describes the requirements for maintenance of restraining rails in other than special track work. Where bolt-on type guards or guarding restraining rails on regular track are used, this section shall apply. Within special track work, the requirements of Section 12 shall apply.

11.1 Restraining rail guard face gage

Where double-guarding restraining rails are used, the guard face gage shall be maintained within the limits shown in **Table 14**.

TABLE 14

Double Guarding Restraining Rails Guard Face Gage (Difference from design)

Class of Track	Operating Speed	Priority	Double-Guarding Restraining Rails Guard Face Gage
1	Less than 15 mph	1	+½ inch
2, 3	16 to 55 mph	2	+¾ inch

RTD MOWs shall designate where restraining rails are to be used specifically for guarding purposes. A record of these locations shall be kept on file.

11.2 Restraining rail maintenance standards

In no case shall the minimum flange way width on restraining rails be allowed to be less than 1½ in., except as provided for in Section 11.1. For exceptions, see the “Note on alternate practices.”

12. Special track work

12.1 General requirements

In turnouts and track crossings, all fastenings shall be intact and maintained to keep the components securely in place. Each switch, frog and guardrail area shall be kept free of obstructions that may interfere with the passage of wheels. The rail bases must be inspected at the area of the rail fastener to determine if there is movement in the rail affecting the position of the switch points and frogs.

12.1.1 Longitudinal rail movement

Tracks shall be equipped with rail anchoring through and on each side of track crossings and turnouts to restrain rail movement affecting the position of switch points and frogs.

12.1.2 Minimum flange way

Flange way at turnouts and track crossings shall be at least 1½ in. For exceptions, see the “Note on alternate practices.”

12.2 Switches

- a) Each stock rail must be securely seated in the switch plates, but care must be used to avoid canting the rail by overtightening the rail braces.
- b) Each switch point shall fit and face up closely and accurately against its stock rail with the switch stand or switch machine in either of its closed positions, to allow wheels to pass the switch points without striking them. In switches with planed points (AREMA design with undercut stock rail), the point must be completely under the stock rail between the actual point of switch and the #2 track rod when the point is in the closed position. The first 6 in. of the point should not be visible when looked at from above and must not under any circumstances be higher than the top of the stock rail. Any signs of unusual wear on the first 6 in. of the point must be carefully investigated to determine and promptly eliminate the cause. Lateral and vertical movement of a stock rail in the switch plates, or of a switch plate on a tie, must not adversely affect the fit of the switch point against the stock rail.



- c) Immediate protection and prompt corrective action are necessary when a switch point is found to stand open against its stock rail.
- d) Any lip formation on the gage side of the stock rail along its undercut area must be promptly corrected to ensure that the switch point fits tightly against the stock rail.
- e) Each switch must be maintained so that the outer edge of the wheel tread (especially in worn wheels with “false flange” conditions) cannot contact the gage side of the stock rail.
- f) The heel of each switch point must be secure, and the bolts in each heel must be kept tight.
- g) Each switch stand and connecting rod must be securely fastened and operable without excessive lost motion.
- h) Each hand-throw lever must be maintained so that it cannot be operated while the lock is in the keeper.
- i) Each switch position indicator must be clearly visible at all times.
- j) Switch points must be replaced when the raised portion of the switch point is worn down to the top of the stock rail (in general, the raised portion of the switch point starts after the second track rod and ends past the heel of the switch; the maximum rise of the switch point over the top of the stock rail in this area is $\frac{1}{4}$ in.). In addition, if the tip of the switch point, with the point set against its stock rail, is higher than the top of the stock rail, then both the point and the stock rail must be replaced.
- k) Unusually chipped or worn switch points must be repaired or replaced. Metal flow on stock rails must be removed by grinding to ensure proper closure.
- l) Immediate protection and corrective action are necessary when a switch point is found to have an unprotected flat vertical surface of $\frac{5}{16}$ in. or more in width and at a depth of $\frac{3}{4}$ in. or more below the top of the stock rail.
- m) The chipping or wear along the top of the switch rail is to be investigated and a cause determined. If the chipping of the switch rail was caused by a lip on the stock rail, then the lip must be removed at once. The switch rails may be retained in place, provided that the chipping does not approach the above criterion.
- n) All flange ways must be at least $1\frac{1}{2}$ inches wide and not to exceed $2\frac{3}{8}$ in. wide in sharp radius curves.
- o) Special design switches, which by design exceed maximum allowable gage limits, are permitted where operating speeds do not exceed 15 mph.

12.3 Frogs, general

12.3.1 Flange way depth

Flange way depth is measured from a plane across the wheel-bearing area of a frog. Flange way depths shall be maintained as follows:

- a) Where operating speeds do not exceed 15 mph, the flange way depth shall not be less than $1\frac{3}{8}$ in.



- b) Where operating speeds exceed 15 mph, the flange way depth shall not be less than 1½ in.
- c) Where frogs are designed as flange-bearing, the flange way depth may be less than the minimum prescribed herein; however, the operating speed may not exceed an appropriate restrictive speed (not greater than 15 mph).

12.3.2 Damaged frogs

- a) If a frog point is chipped, broken or worn more than 5⁄8 in. down and 6 in. back, then the operating speed over the frog shall not exceed 10 mph.
- b) If the tread portion of a frog casting is worn down more than 3⁄8 in. below the original contour, then operating speed over that frog shall not exceed 10 mph.
- c) All fins and lips of metal flow must be ground promptly, and flange way widths restored to the standard dimensions.
- d) Any lateral movement in excess of ¼ in. must be corrected immediately.
- e) Cracks in manganese castings must be reported immediately to a track supervisor. Frog castings with shrinkage marks or casting defects not in the wheel bearing surface should be closely monitored. All other cracked frog castings should be welded or removed from service.

12.3.3 Spring rail frogs

Spring rail frogs shall be maintained as follows:

- a) The outer edge of a wheel tread shall not contact the gage side of a spring wing rail.
- b) The toe area of each wing rail shall be solidly tamped and fully and tightly bolted.
- c) Each frog with a bolt hole defect or head-web separation shall be replaced.
- d) Each spring shall have compression sufficient to hold the wing rail against the point rail.
- e) The clearance between the hold-down housing and the horn shall not exceed ¼ in.

12.3.4 Self-guarded frogs

Self-guarded frogs shall be maintained as follows:

- a) The raised guard on a self-guarded frog shall not be worn more than 3⁄8 in.
- b) If repairs are made to a self-guarded frog without removing it from service, then the guarding face shall be restored before rebuilding the point.

12.4 Guardrail gages in frogs

The guard check and guard face gages in frogs shall be within the limits prescribed in **Table 15**.



TABLE 15

Guard Check and Guard Face Gages in Frogs (Difference from design values)

Class of Track	Operating Speed	Priority	Guard Check Gage Shall Not Be Tighter Than	Guard Face Gage Shall Not Be Greater Than
1	Less than 15 mph	1	-½ inch	+½ inch
2	16 to 30 mph	2	-¾ inch	+¾ inch
3	31 to 80 mph	2	-¼ inch	+¾ inch

12.5 Special work

Any track work in the vicinity of an electrically controlled switch that may change switch point adjustment must not start unless the signal department is notified. Any switch placed out of service for track work must not be returned to service unless proper point pressure and adjustment are provided. When working under traffic, switches shall be blocked, clamped or spiked to prevent switch point gapping.

13. Street-running track work

This section describes the inspection and minimum requirements unique to street-running embedded track. This section either modifies or adds to requirements contained within the preceding sections. Unless specifically amended by the information contained within this section, all other sections of this standard shall govern. Street-running track is commonly referred to as embedded track or paved track.

13.1 Inspection

- a) Tracks used by revenue trains shall be inspected weekly on foot or by riding over the track in a vehicle at a speed that allows detection of noncompliance with standards. In the unusual event that a walking or riding inspection cannot be performed, a qualified person must inspect from a revenue vehicle in a position in full view of the roadbed. Required inspections must be performed by a qualified person as prescribed by Section 2. An interval of at least three but not more than 11 calendar days may elapse between inspections.
- b) Tongue and mate switches are to be inspected weekly with at least three but not more than 11 calendar days between inspections.

13.2 Roadbed

Street rights-of-way must be maintained in such a manner that potential hazards to train traffic, as well as to automotive traffic and to pedestrians, are minimized. Street rights-of-way may have a few special considerations that are only peripherally related to track inspection and maintenance, but that could have a detrimental effect on track performance or rail vehicle traffic. The general condition of track area and paving shall be observed, and if any of the following conditions are found, which may jeopardize the safe movement of vehicles or pedestrians, corrective actions must be taken.

1. debris in the vicinity of track, particularly in the flange way and the area of track special work
2. flange way blocked with foreign material resulting in the wheel lifting to a level such that the wheel is no longer properly riding on the designed rail profile



3. street surface higher than the top of rail that could result in equipment being stuck or damaged
4. drainage and ventilation grates, manhole covers, crosswalk pavers, passenger platform materials and other such objects found to be fouling the track or obstructing the track in any way
5. undermined track

If the conditions listed below are found, then the inspector shall identify the condition on the track inspection report:

1. loose cobblestones, pavers or bricks
2. potholes
3. low paving around rails

13.3 Track geometry

13.3.1 Gage

Measurements for track gage on rail may vary from that outlined in Section 8.1. In the event a different measurement for gage is used, the RTD MOW shall document this measurement and the corresponding gage tolerances unique to its specific design, subject to the conditions of the “Note on alternate practices.”

13.3.2 Track flange way

Street track should have as much flange way depth as the type of construction will allow and in accordance with the appropriate design of the system. Flange way depth shall be monitored to ensure that rail wear or flange way debris does not create a flange-bearing condition. This is especially critical in areas that are subject to freezing temperatures, that water is not allowed to form ice in the flange ways in the fall and winter. Any obstructions to the flange way should be removed as soon as possible. If part of the track structure (i.e., elastomeric booting, rubber material, asphalt, concrete, etc.) has begun to obstruct or diminish the depth of the flange way, then the problem should be addressed on a programmed basis, in accordance with the severity of the situation. Such situations shall require periodic measurement and monitoring until corrected. Any flange way depth problem or obstruction that would result in wheel climb or potential derailments must be rectified immediately.



13.4 Track structure

Inspection of individual components is neither reasonably accomplished nor usually necessary, except for the rail. When deterioration of the track, identified by defects in gage, alignment and profiles described in Section 8, Section 10, Section 11 and Section 12 herein are found, repair of supporting structure shall be performed to correct the defects. Any temporary repairs to correct these conditions should be replaced with permanent structural repairs within 48 hrs. and vehicle civil speed should be adjusted as needed or supervision provided while operating over temporary repairs.

Special attention shall be given to the maintenance of track clearances as required by the car and line equipment clearance diagrams. Any street furniture or other appurtenances shall be monitored to ensure that there is not encroachment to the dynamic envelope of the vehicles, including MOW equipment.

Street or infrastructure repairs by others (DOT, contractors, any third party) must be monitored to make sure that the trackway structural integrity is not violated and that proper operating clearances are maintained during and after construction.

13.5 Rail

13.5.1 Rail defects

If conditions listed below are found, then a qualified person is to identify the conditions on the track inspection report and perform the action(s) shown in Table 16. Rail defects such as excessive wear, engine burns, “squats,” head checks, corrugation and excessive flange way shall be handled in accordance with the standards shown in Section 10 of these specifications.



TABLE 16
Embedded Rail Defect Remedial Action

Type of Defect	Length	Maximum Speed	Priority	Minimum Remedial Action
Broken rail on guard – no movement	N/A	5 mph	2	Repair within 24 hours
Broken rail on guard – movement/pumping	N/A	Out of service	1	Repair immediately; replace rail
Missing head/rail breakout	Up to 2 inches	10 mph 5 mph Out of service	3	Schedule repairs
	2 inches to 4 inches		2	Repair within 24 hours
	4 inches		1	Repair immediately; replace rail
	More than 4 inches			
Cracked rail, broken joint/or cracked weld area	Up to 4 inches	10 mph	3	Re-inspect in 7 days
	4 inches or more	10 mph	2	Re-inspect daily and repair within 7 days
	10 mph			
Guard breakout	Up to 1 inch	5 mph	2	Repair within 24 hours
	More than 1 inch	Out of service	1	Repair immediately; replace rail
Cracked broken tram	Any length	Out of service	1	Schedule repairs as defect warrants



13.5.2 Rail wear

Rail gage face wear, head width and vertical wear shall be measured at the gage line, etc. as appropriate for the RTD MOW's rail section. Care must be used in not allowing wheel tread to touch roadway material. Top wear is based on keeping the top of the rail above the road surface.

13.6 Special track work

Street switches, crossovers and crossings must be free of debris.

All non-flange-bearing parts of street special work will be maintained to have a flange way as described in Section 13.3.2.

The transition area (or riser) into and out of flange-bearing special work should be maintained to provide as smooth a transition as possible and within any prescribed

maintenance limits. Proper transition will usually be evidenced by a gradual takeoff and re-entry of the wheel tread on the railhead, just before and after the flange-bearing special work (that is, the worn area on the railhead will taper more gently). Poor transition will also be evidenced on the facing side of the special work (in the normal direction of rail traffic) by excessive wear at the transition point. In the worst cases, a significant impact may be exhibited as wheels enter or exit the flange-bearing area. This would be evidence of a very poor transition and would necessitate prompt attention.

Tongue and mate switches shall be monitored, and if conditions listed below are found, a qualified person is to identify the conditions on the track inspection report and to perform the action(s) shown in **Table 17**.

TABLE 17

Tongue and Mate Switch Conditions

Condition	Required Action
Tongue vertical wear	
$\frac{3}{16}$ inch below casting	Schedule for replacement
$\frac{1}{4}$ inch below casting	Replace within 30 days
Sharp edge	Grind within seven days to restore contour
Loose heel	Schedule to retighten within three days
Mate false grooves	
Over $\frac{3}{16}$ inch	Repair within seven days
Split through risers	Repair within 24 hours
Wheel cuts in switch casting	
$\frac{3}{16}$ inch	Repair within 30 days

14. Elevated track

This Section describes specific elements, inspection and maintenance practices to be followed regarding elevated tracks. The term “elevated track” refers to special types of track design or construction for tracks placed on elevated structures, generally open-deck steel structures similar to open-deck bridges, as well as to tracks placed in aerial viaducts of concrete or steel structures.

14.1 Types of structures

- a) **Viaduct:** Typically, a concrete structure with ballasted or direct fixation track, with or without sidewalls (parapet walls).
- Sidewalls (parapet walls): These could be structural or non-structural.
 - Without sidewalls, the edges of the structure are approximately at the same height as the top of the running rail.

14.2 Emergency protection rails (inner bridge guardrails)

Emergency protection rails (also called inner bridge guardrails by AREMA) are typically made of either timbers (lagged to the top surface of the crossties at their ends), steel angled members or rails laid between the two running rails in the gage of the track to prevent derailed cars from falling over the edge of the structure or to prevent a derailed car from severely damaging certain key structural members along the right-of-way.

Installation of emergency protection rails shall be in accordance with the following:

- a) Viaduct structures: If there are no structural sidewalls, then two emergency protection rails shall be installed on the tracks adjacent to the edge of the structure if the distance from the edge of the structure to the gage side of the running rail closest to the edge of the structure is less than half of the width of the rail transit’s car plus 1 ft. If there are structural sidewalls (parapet walls), then emergency protection rails may be omitted. In station platform areas, only one emergency protection rail shall be laid adjacent to the platform edge side of the track; the other emergency protection rail shall end a minimum of one car length inside the confines of the platform.
- b) On curves with restraining guardrails, only one line of emergency protection rails may be required, positioned closer to the low side of the curve.




- c) In general, emergency protection rails shall end at least a minimum of one car length beyond the ends of the structure on which it is laid.
- d) Emergency protection rails shall be continuously laid, except through switches and special track work, expansion joints and other track and signal appurtenances. The ends of the emergency protection rail shall be cut out and the rail head bent down at locations where signal equipment or other track appurtenances are located, to prevent dragging equipment from catching on it. Emergency protection rail ends should rest on a crosstie and be securely spiked. Thermal expansion and contraction of the emergency protection rails shall be addressed by adequate means.
- e) Emergency protection rails shall be fastened to each crosstie with at least one spike on each side of the rail; spikes shall be offset to avoid splitting of the crosstie.
- f) Emergency protection rails shall be laid at a distance from the gage of the running rail such that proper equipment clearances are maintained, enough distance from the running rail is provided for a derailed wheel not to climb over fasteners or other ancillary equipment, and enough room to install and maintain track appurtenances is provided.
- g) The top of the emergency protection rails shall be not higher than the top of the running rails and be not more than 1 in. lower than the top of the running rails.
- h) Missing or ineffective emergency protection rails shall be classified as follows:
 - In subway, open cut or at-grade tracks missing or ineffective emergency protection rails shall be classified as a Priority 3 condition.
 - In elevated structures, missing or ineffective emergency protection rails shall be classified as a Priority 2 condition, except at side station platform areas in local tracks where it shall be classified as a Priority 3 condition as long as there are emergency protection rails properly installed beyond the ends of the station platform.

14.3 Walkways and handrails

Each RTD MOW shall have standards specifying the requirements for installation of walkways and handrails at locations where they are needed.

- a) Walkways shall be installed to adequately support personnel and materials on elevated track installations. Excessive gaps or openings in slating or walkways shall be covered adequately, where practicable; if covering cannot be performed, then the edges adjacent to the opening shall be marked as per paragraph h) below.
- b) Where walkways are required, the minimum width of the walkway shall be 2 ft., 0 in., at the walking surface.

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- c) Where walkways are installed on the outside of a bridge or open-deck elevated structure, railings supported by posts shall be installed to provide for protection. The top of the railing shall be not less than 3 ft., 6 in., from the top of the walkway. An intermediate railing shall be placed not more than 1 ft., 9 in., above the top of the walkway. Additionally, kickplates or similar devices such as toe boards shall be installed along the surface edge of the walkway to prevent small objects placed on the walkway to fall down below. If walkways are installed between two or more tracks on open-deck steel structures, no railing may be installed.
 - d) Walkways, posts and handrails shall be designed, fastened and spaced to provide adequate support and fall protection to passengers and personnel as well as materials placed along the walkway.
 - e) Defective walkway shall be defined as that which is damaged, broken, split, weathered or burnt to the extent that adequate support to personnel and material is not provided.
 - f) A defective walkway that has been identified as such shall be clearly marked with bright red or orange paint until it is replaced or repaired.
 - g) Gaps in railings on elevated tracks shall be marked with bright red or orange plastic warning barrier fence and protected with rope until permanent repairs are made.
 - h) Any defective railing components shall be replaced as soon as practicable, and within no more than 90 days of their identification as defective. In any case,

such defective components shall be marked with bright red or orange paint and, if needed, bright red or orange ribbon and rope shall be placed around the area. If the 90 days are exceeded, then the supervisor in charge of the section will re-inspect the railing with a frequency not to exceed 30 days until repairs or replacements have been completed.

14.4 Rail expansion joints (slip rails) on elevated structures

- a) Each RTD MOW shall develop standards for the application of rail expansion joints (slip rails) on elevated structures. Standards shall also include the maintenance, inspection and replacement of the rail expansion joints.
- b) Typically rail expansion joints shall be used in pairs, one on each running rail, directly opposite to each other.
- c) Rail expansion joints shall be assembled in such a way that they are at the approximate midpoint of their range of movement at a specified mean temperature between the extreme temperature values experienced at that location.
- d) Rail expansion joints shall be designed to minimize resistance to the expansion and contraction of the structure. Typically, they should be inspected and maintained with the same frequency and level of detail required for special track work.
- e) Temporary or permanent removal of rail expansion joints shall be authorized only by the chief engineer of the RTD MOW.



14.5 Installation of CWR on elevated structures

- a) The RTD MOW shall perform an engineering study analyzing the feasibility of installing CWR on elevated structures, paying particular attention to expansion issues (both rail and structure), thermal stresses, acceleration and braking (train dynamics), need for expansion joints, transitions between elevated structure and other types of structures, connection to bolted rail and special work portions, etc.
- b) The RTD MOW shall develop standards for the inspection, maintenance and replacement of CWR on elevated structures, paying particular attention to thermal distressing, anchoring of CWR, need for rail expansion joints, etc.
- c) Care shall be taken that CWR (or rail longer than the standard length of 39 ft.) is not installed bridging structural expansion joints unless a detailed engineering analysis is performed and the feasibility of such installation is demonstrated.

References





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AREMA Manual for Railway Engineering, Volume 1, Chapter 5.

Definitions





Definitions

The following terms are presented here to offer an understanding of the railway and roadway terminology relevant to these and other standards and documents referenced in the previous sections:

adzing machine: Portable, power-operated machine designed to adze the rail seat on ties to provide proper bearing for rail or tie plates.

aerial structure: Any system structure that carries transit tracks and spans above land or water surfaces.

alarm condition: Any abnormal condition that requires the attention or intervention of responsible personnel or an individual monitoring the transit system operation.

alignment: The horizontal location of track as described by curves and tangents.

anchor, backup: A rail anchor applied to control rail movement during anchoring procedures.

anchor bolt: A bolt or threaded rod that holds a direct fixation fastener to supporting concrete. An anchor bolt is fastened into a female insert in the supporting concrete. A threaded rod may be cast or grouted into the supporting concrete.

anchor, box: Four rail anchors on the running rails at one tie with two anchors on each rail, one on each side of the tie.

anchor, contact rail: An insulated assembly attached to both the contact rail and invert or ties to restrain the contact rail against thermal movement in the longitudinal direction.

anchor, rail: A device installed on the rail base designed to resist longitudinal rail movement due to traffic and temperature variations.

angle, frog: The angle formed by intersection gage lines of a frog.

angle, switch: The angle between the gage lines of the switch rail at its point and the stock rail.

approach slab: A concrete slab located at an aerial structure abutment or tunnel portal, to provide a transition from direct fixation track to ballasted track.

asphalt cement: A fluxed or un-fluxed asphaltic material, specially prepared as to quality and consistency, suitable for direct use in the manufacture of asphaltic pavements and having a penetration of between 5 and 250.



at-grade section: Roadbed, generally at the same level as the surrounding area, on which ballasted track is constructed.

average ambient temperature: The average of temperature readings taken every three hours for a 24-hour period immediately preceding the work.

ballast: Granular material placed in the track bed to support and restrain the track, and to provide drainage.

ballast impedance: See *impedance, ballast*.

ballast leakage: The leakage of current from one rail of a track circuit to the other through the ballast, ties, etc.

batter: The deformation of the surface of the head of the rail in the immediate vicinity of the rail end.

bolted fastener system: Any fastener system containing a bolt (exclusive of anchor bolts) to hold the elastic rail clip in position.

bond, impedance: An iron core coil of low resistance and relatively high reactance, used to provide a continuous path of the return propulsion current around insulated joints and to confine the alternating current signaling energy to its own track circuit.

bond, inductive coupled impedance: A device of low resistance and high reactance, used with jointless audio frequency track circuits to couple inductively and to confine the signaling energy to its own track circuit and to equalize the return propulsion current between rails without impeding its flow.

bond, propulsion: A conductor of low resistance providing a path for the return propulsion current at non-insulated joints.

bond, signal: Conductor of low resistance providing a path for track circuit current across bolted rail joints.

bonded fastener: A resilient fastener in which the elastomeric material is bonded to a steel top plate and a steel bottom plate. A common manufacturing practice is to apply an adhesive to the steel plates, place the plates in the mold with the compounded but uncured elastomer, and then conduct the elastomer curing. Bonding and curing occur in the same process.

bonded joint: A rail joint that uses high-strength adhesives in addition to bolts to hold the rails together.

bonding (rail): The connection of rail or frogs to provide a continuous path for signal or propulsion current by use of bonds.

book of rules: A set of codified regulations and procedures by which operating personnel are governed.

bridge, ballasted: A bridge on which ballasted track is constructed.

bridge, non-ballasted: A bridge having a steel or concrete surface on which direct fixation track is constructed.

bridge tie: A transverse timber resting on the stringers and supporting the rails.

bumping post: A device attached to the rail designed to stop a rail vehicle at the end of a track.

bumping post signal: See *signal, bumping post*.

burrs: The rough edges left at the end of a rail when sawed, or on the side of the web when drilling bolt holes.



cant: The inward inclination of a rail, affected by the use of inclined-surface or tie plates, usually expressed as a rate of inclination, such as 1 in 40.

carbon steel (or plain steel): Steel containing only the elements carbon, manganese, phosphorus, sulfur and silicon in addition to iron, the properties of which are due essentially to the percentage of carbon in the steel.

catenary: An overhead contact wire system from which a transit vehicle collects propulsion and auxiliary power.

central control: That place from which train control or train supervision is accomplished for the entire transit system; the train command center.

clearance diagram: A diagram that establishes the minimum safe distance between all points on a moving vehicle and fixed wayside structures or appurtenances.

clearance: The distance between specified points along the tracks and specified points on moving vehicles.

clip: See *elastic rail clip*, *rigid rail clip*.

closure rails: The rail between the heel of a switch and the toe of a frog in a turnout.

compound fissure: A progressive fracture originating in a horizontal split head, which turns up or down in the head of the rail as a smooth, bright or dark surface, progressing until substantially at a right angle to the length of the rail. Compound fissures require examination of both faces of the fracture to locate the horizontal split head from which they originate.

compromise joint (bar): Joint bars designed to connect rails of different fishing height and section, or rails of the same section but of different joint drilling.

construction, fire resistant non-combustible: Non-combustible construction that has a fire resistance rating through application of a protective fire-resistive membrane such as masonry or concrete to supporting steel.

construction, non-combustible: Construction minimizing the hazards of fire by the use of non-combustible materials for structural elements or assemblies, and by limiting the amount of combustible materials that are incorporated into the building construction.

contact rail: See *third rail*.

continuous welded rail (CWR): A number of rails welded together into various lengths.

controlled cooling: A method of controlling the cooling rate of steel products. For rails, this is accomplished by placing 75 to 100 rails in an insulated container.

corrosion: The dissolving or eating away of the surface of metal through chemical action, either regularly or slowly as by rusting, or irregularly and rapidly as by pitting and grooving.

corrugated rail: A wear condition on the railhead of alternate peaks and hollows, which may develop in service under certain conditions.

cover board: A fiberglass cover over the contact rail to protect personnel from accidental contact with the rail.



cover board bracket: A fiberglass bracket attached to the base of the contact rail to support the cover board.

creosote: As used in wood preserving, a distillate of coal tar produced by high-temperature carbonization of bituminous coal. It consists principally of liquid and solid aromatic hydrocarbons and contains appreciable quantities of tar acids and tar bases; it is heavier than water and has a continuous boiling range of at least 257 °F beginning at about 392 °F.

crib: The space between two adjacent ties.

cropping: Cutting metal from the end of an ingot, bloom or rail during the process of rail manufacture. Also, cutting of the ends of used rails to eliminate battered or damaged portions.

cross level: The vertical relationship of the top of one running rail to that of the opposite running rail at the same location on the track.

crossing at grade: An intersection of two or more tracks at the same elevation.

crossover: A pair of turnouts with track between them, connecting two nearby and usually parallel tracks.

crushed head: A flattening or crushing down of the head of a rail.

current, foreign: Stray electrical currents that may affect a signaling system but that are not a part of the system.

current, leakage: An electric current that flows through or across the surface of insulation when a voltage is impressed across the insulation.

curve, circular: A horizontal curve, formed by a portion of a circular arc specified by its radius or degree of curve and length, with the following points:

1. PC: Point of curve.
2. PT: Point of tangent.
3. PI: Point of intersection of the tangents

curve, spiral: A transition curve connecting a tangent to a circular curve.

1. ST: Spiral to tangent.
2. TS: Tangent to spiral

curve, vertical: A parabolic curve connecting different profile grades.

1. **PIVC:** point of intersection of the grades

cut and cover: A method of constructing an underground structure, mostly tunnels, by excavating from the surface, placing the structure, and then backfilling and restoring the original surface.

dap: A recess cut into a tie.

de-energize: To deprive an electro receptive device of its operating current.

degradation: Falling from an initial level to a lower level in quality or performance.

depth: The depth of the wheel flange passageway, or the vertical distance from the top of the tread portion and guard portion of a track structure.

derail: A device designed to cause rolling equipment to leave the rails.

derailment: The condition of rolling equipment leaving the rails.



design safety: Safety achieved by integration of safety features into the system designed characteristics to prevent operation except in the manner intended to be safe.

designated authority: The titled position charged with responsibility of supervising, authorizing, directing and/or controlling train movements and other facets of operations, often from a central location. The local company title should be used in place of “designated authority.”

detail fracture: A progressive fracture originating at or near the surface of the railhead. These fractures should not be confused with transverse fissures, compound fissures or other defects, which have internal origins. Detail fractures usually have their origins in the following types of defects, and progress crosswise into the head of the rail:

1. shell where a thin shell of metal becomes separated from the head, usually at the gage corner
2. head checks usually at or close to the gage corner where movement or flow of the surface metal is sufficient to start a hairline crack

detector, ground: A device for detecting a ground on an electrical circuit.

detector, point: A circuit controller that is part of a switch operating mechanism and operated by a rod connected to a switch, derail or movable point frog, to indicate that the point is within a specified distance of the stock rail.

detector track circuit: A track circuit within an interlocking that, when occupied by a train, prevents the position of a train switch from being changed.

diamond: A special track work assembly consisting of two end frogs and two center frogs, which comprise the central portion of a double crossover.

direct fixation fastener: A sub-category of elastic fastener in which the rail fastener attaches immediately to a rigid support (concrete, invert, concrete deck, floating slab, open-deck structure). Direction fixation systems are systems used on other than ballasted track. Resilient fasteners and embedded concrete blocks with elastomeric boots (embedded in invert concrete pockets) fall within the general definition of direct fixation fasteners.

direction, normal: The designed predominant direction of train traffic as specified by the rules.

direction, reverse: Train movement against the normal direction of traffic.

double crossover: 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.

dress: To shape and trim the ballast to the required cross-section.

elastic fastening system: Any rail fastening system that includes an elastic rail clip.



elastic rail clip: A mechanical spring designed to hold a rail to its support (tie plate, elastomer plate, tie, etc.) providing continuous contact with the rail and the rail support during restraint or rail rotation and longitudinal rail movement. Equivalent terminology: rail clip, elastic clip.

elastomer: Any member of a class of synthetic polymeric substances that, in the vulcanized state, can be stretched repeatedly to at least twice its original length and, upon release of the external load, will immediately return to approximately its original length.

elastomer pad: An assembly placed in the contact rail at approximately 1000 ft. intervals to accommodate thermal expansion and contraction of the rail.

elastomer plate: See *bonded fastener*.

embedded wood block systems (in concrete inverts): A type of track is used generally in subway or viaduct track construction in which each rail is supported by short tie blocks embedded directly in a monolithic concrete slab. Some systems also use a long crosstie every fourth or fifth block in order to connect both rails and ensure proper track gage during construction. Elastic or resilient fasteners are generally used with this type of track.

end chipping: The loosening of metal at the top of gage side at the end of a rail.

end flow: Projection of metal into the end gap at the railhead.

end hardening: Heat treatment of the top of rail ends, to minimize batter.

facing movement: See *movement, facing*.

facing point lock: A mechanical lock, for a switch, derail or movable pint frog, comprised of a plunger stand and a plunger, which engages a lock rod attached to the switch point to lock the operated unit.

facing point, switch: See *switch, facing point*.

fastener body: An elastomeric plate; a bonded fastener; the rail support component of a resilient fastener system. The term “fastener body” refers to a single component of bonded steel and elastomer. The fastener body provides the rail support in a resilient fastener system.

fastener vertical spring rate: Also called **vertical static stiffness**, represents the slope of the load-vs.-deflection curve of the fastener over a prescribed range of loads (usually 1000 lbf to 12,000 lbf). Modern resilient fasteners achieve good results regarding noise and vibration attenuation, as well as a track modulus similar to that of good ballasted track, by limiting the static vertical stiffness of the fasteners to no more than 100,000 lbf/in.

fastenings: Clips, pads, insulators, joint bars, bolts and spikes.

female insert: An internally threaded component that is designed to anchor a threaded fastener such as an anchor bolt into a concrete support.

field side: The side of the rail farthest from the center of track.

fixed way: All wayside appurtenances.

flaggers: Personnel assigned to control the movement of trains by the display of hand signals, flags or lights.



flange way: The space between the running rail and the guardrail or restraining rail adjacent to it that provides a passageway for wheel flanges.

floating slab: A concrete slab supported by a resilient foundation and designed to support direct fixation track and special track work in a manner that will dampen vibrations.

flowed head: A rolling out of the metal on the head of the rail toward the sides without showing any indication of breaking down of the head structure.

fouling point: The location near a turnout marking the safe passing clearance with another track.

frog: A track structure used at the intersection of two running rails to provide support for wheels and passageways for their flanges, thus permitting wheels on either rail to cross the other.

frog, movable point: A frog equipped with points, which are movable in the same manner as the points of a switch.

gage (gauge): The distance between rail gage lines, measured at right angles.

gage line: A line $\frac{5}{8}$ in. below the top of the centerline of head of running rail along that side that is nearer the center of the track.

gage (of track): The distance between the gage lines, measured at right angles thereto. Standard gage in North America is $56\frac{1}{2}$ in.

gage side: The side of the rail nearest the center of track.

grade: The amount of rise or fall of the track in a specified length, usually 100 ft.. For example, a rise of 2 ft. in elevation along 100 ft. of track constitutes a 2 percent grade.

guard check gage: The distance between guard line and gage line, measured across the track at right angles to the gage lines.

guard face gage: The distance between guard lines, measured across the track at right angles to the gage lines.

guard line: A line along that side of the flange way that is nearer the center of the track and at the same elevation as the gage line.

guard rail: A rail laid parallel with the running rails to prevent wheels from being derailed, or to hold wheels in correct alignment to prevent their flanges from striking the points of frogs or switches and to reduce the wear of the high rail in curves.


guard rail (track): A rail or other structure laid parallel with the running rails of a track to control a derailed train. . Also called emergency protection rail.

guideway: That portion of the transit line included between the outside lines of curbs, or shoulders, underground tunnels, cut or fill slopes, ditches, channels, waterways and including all appurtenant structures.

hand-signal: See *signal, hand*.

hand-throw switch: See *switch, hand-throw*.

hazard: Any existing or potential condition that can cause injury or death, or damage to or loss of equipment or property.



hazard level: A qualitative measure of hazards stated in relative terms:

Category I, Negligible: Will not result in personal injury or system damage.

Category II, Marginal: Can be counteracted or controlled so that no injury to personnel or major system damage will be sustained.

Category III, Critical: Can be mitigated but could cause damage or injury

Category IV, Catastrophic: Will cause death to personnel.

heartwood face: The side of a timber tie about which the growth rings are concave.

heel length: The distance between the ½ in. point of a frog and the heel, measured along the gage line.

heel of frog: The end of a frog farthest from the point of switch.

heel of switch: That end of a switch rail farther from the point and nearer the frog.

heel spread: The distance between gage lines at the heel.

helicoidal spring lock washer: A washer design with one or more coils within the general class of springs that accommodate compression loading (as compared with springs designed for tension loading or torsional loading). Some lock washers incorporate a bolt or nut engagement protrusion (a sharp edge or serrations) intended to supplement bolt/nut back-out friction resistance.

hi-rail: Attachments that make rubber-tired vehicles (trucks, autos, special work equipment) capable of operating on rails.

high-restraint fastener: Elastic fastener systems with maximum longitudinal rail restraint allowed by the particular fastener design. Generally, the term is invoked in projects that use both a low and/or zero restraint system and a normal, maximum restraint fastener. The term distinguishes between the normal fastener and the low-restraint fastener or zero-longitudinal restraint systems deployed on that project.

horizontal split head: A horizontal progressive defect originating inside the railhead, usually ¼ in. 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 railhead.

impedance, ballast: The impedance shunting of a track circuit due to the condition of the ballast.

impedance bond: See *bond, impedance*.

in-house maintenance: The repair, overhaul and testing services provided to an operating property by its own employees in its own facilities.

incident: An unforeseen event or occurrence that does not result in injury or property damage.



inner guardrail: A longitudinal member, usually a metal rail, secured on top of the ties inside the running rail to guide derailed car wheels. Also called emergency protection rail.

inspection: The checking or testing for condition, performance and safety of equipment against established standards.

Insulated joint: A rail joint designed to arrest the flow of electric current from rail to rail by means of insulation so placed as to separate rail ends and other metal parts connecting them.

insulated rail joint: See *joint, insulated rail*.

insulator, contact rail: A non-conducting body of porcelain or fiberglass that supports the contact rail.

insulator, rail fastener: An insulating component between the elastic clip and the top of the rail base, overlapping the rail base edge and interlocking with the fastener's body or shoulder. Same as rail insulator. See also shoe.

insulator base: The base of the insulator assembly attached to the invert or ties.
insulator cap: The top of the insulator assembly where the contact rail sits.
interlocked switch: See switch, interlocked.

interlocking: An arrangement of signals and signal appliances, so interconnected that their movements must succeed one another in proper sequence.

interlocking, automatic: An interlocking controlled by circuit log so that movement succeed one another in proper sequence without need for manual control.

joint, rail: A mechanical fastening for rails, composed of steel bars and bolts.

joint, insulated rail: A rail joint in which electrical insulation is provided between adjoining rails.

junction: A location where train routes converge or diverge.

ladder track: A track connecting successively the body of consecutive tracks of a yard.

lead: The distance between the actual point of the switch and the ½ in. point of the frog.

lead curve: The curve rail (also called the closure rail) in a turnout placed between the switch point and the frog.

line: Condition of the track in regard to uniformity in direction over short distances on tangents, or uniformity in change of direction over short distances on curves.

line end: The end of any tie from which all measurements are made.

line side: The side of the track along which the line ends of all the crossties are evenly located in a line parallel to the centerline of the track.

lining track: Shifting track laterally to conform to the established alignment.

locomotive: A prime mover for towing work cars or moving transit vehicles, generally in the 50-ton and less- than-100-horsepower class.

low-restraint fastener: Elastic fastener systems designed with less longitudinal rail restraint than potentially available from the fastener design. Low-restraint fasteners are applicable on tall aerial structures to reduce



longitudinal load transfer to piers, thereby reducing structure construction costs. See also zero longitudinal restraint systems.

lubrication: The application of lubricants, generally on a scheduled basis, to equipment and machinery.

machine: A device for power operation of switches, usually dual controlled for power or hand operations.

machine, interlocking: An assemblage of manually operated levers or equivalent devices for the control of signals, switches or other units, including mechanical or electric locking or both to establish proper sequence of movements.

main track: See *track, main*.

maintenance: The upkeep of vehicles, plant, machinery and equipment. It may be scheduled, planned, progressive or periodic based on pre-established intervals of time, hour or mileage and employing pre-printed checklists, or it may be unscheduled or corrective, generally not interval based.

maintenance-of-way department: That functional unit within a maintenance organization that generally has responsibility for track, guideways or structures. It sometimes includes responsibility for maintenance of all transit plants and equipment other than rolling stock.

maintenance-of-way shop: A transit facility expressly designed for maintenance of the plant and equipment within the jurisdiction of a maintenance-of-way department.

maintenance planning system: A system of cost, work and manpower planning, scheduling and control, either manual or

automated and generally part of a total management information system.

malfunction: Any anomaly wherein a system, subsystem or component fails to function as intended.

manganese steel insert: A crossing in which a manganese steel casting is inserted at each of the four intersections, being fitted into rolled rails and forming the points and wings of the crossing frogs.

mid-ordinate (mid-chord offset): The perpendicular distance between the gage line of a rail and the midpoint of a string pulled taut and straight between two points on a curved rail.

monument: A permanent marker accurately defining a point from which the track work geometry may be plotted (i.e., elevation and centerline of the track).

movable point: A crossing of small angle in which each of the two center frogs consist essentially of a knuckle rail and two opposed movable center points with the necessary fixtures.

number, frog: One-half the cotangent of one-half the frog angle or the number of units of centerline length, of which the spread is one unit.

original equipment manufacturer (OEM): The enterprise that initially designs and builds a piece of equipment.

other track material (OTM): Miscellaneous materials required to complete track construction, other than rail, special track work ballast and ties.



out of face (referring to track work): A track maintenance operation that is performed on an entire segment of the track without skipping over any portion of that track segment.

personal protective equipment (PPE): All clothing and other work accessories designed to create a barrier against workplace hazards. Examples include safety goggles, blast shields, hard hats, hearing protectors, gloves, respirators, aprons and work boots.

piped rail: A rail with a vertical split, usually in the web, due to failure of the sides of the shrinkage cavity in the ingot to unite in rolling.

pit: A depressed area below floor level mainly between running rails or guideway for under-car lubrication, inspection and maintenance and equipped with all necessary utilities.

pitting: Localized corrosion.

plate, gage: A steel plate installed on the switch tie at the switch points to secure the stock rails at the correct gage.

plate, riser: A steel plate welded to a special switch plate for the purpose of raising the switch rail slightly above the stock rail.

plates, special: Plates for use in special track work, designed to replace the AREMA standard gage, switch, heel and hook twin tie plates, commonly used under switches and frogs.

point, actual: That end of the switch rail farther from the frog, where the spread between the gage lines of the switch rail and the stock rail is sufficient for a practicable switch point.

point detector: See *detector, point*.

point, half-inch: A point located at a distance from the theoretical point toward the heel equal in inches to one-half the frog number, and at which the spread between gage lines is $\frac{1}{2}$ in. It is the origin from which measurements are usually made.

point of frog, theoretical: The point of intersection of the gage lines of a frog

point of switch, theoretical: The point where the gage line of the switch rail, if produced, would meet the gage line of the stock rail.

point: See *switch point*.

rail anchorage appliance, fixed: Often used with zero- or low-restraint direct fixation fasteners on elevated structures to prevent longitudinal movement of the rail by fixing it at one point using a special device that has a robust, usually bolted connection to the structure and the rail, similar to the “deadman” used to fix crane rails. The anchorage is placed strategically to transfer the least longitudinal load to the structure while still preventing any rail movement; often used to prevent the rail from “running” into a switch or other sensitive track appliance such as a diamond crossing or expansion joint.

rail anchor, general railroad applications: A drive-on, single piece clip that develops high longitudinal rail restraint.

rail brace: A device that provides lateral support on the field side of stock rails to maintain the track gage.

rail brace backing block: The part of a rail brace that is welded to the special switch plate.



rail brace wedge: The part of a rail brace that is driven between the backing block and the stock rail, thereby securing the rail at the desired gage.

rail clamp: A device for securing rails and frogs to special plates. Generally, this term means rigid rail clip. Colloquial use varies.

rail clamp block: The portion of the rail clamp that is welded to the special plate.

rail clamp spring: The portion of the rail clamp that holds the rail or frog to the special plate and is bolted to the rail clamp block.

rail clip: See *elastic rail clip*, *rigid rail clip*.

rail, composite contact: An electrical conductor made of a steel rail section mounted adjacent to the running rail with an aluminum extrusion secured to each side of the steel rail web for supplying DC traction power to the transit vehicles. Sometimes referred to as “third rail.”

rail, continuous welded: A number of rails welded together into a single length.

rail, control-cooled: Rail cooled during manufacture at a controlled rate in an insulated container to prevent the formation of internal defects that may later result in rail breakage.

rail fastening system: A system of components designed to resist lateral and longitudinal rail movement and to restrain rail rotation while providing vertical support. In resilient fastener assemblies, the design provides electrical insulation and filtering vibrations from the rail.

rail, field welded: Rail welded in track using an aluminothermy exothermic (thermite) process.

rail, fully heat-treated: Control-cooled rail specially processed to produce a desired hardness throughout the rail.

rail insulator: An insulating component between the rail clip and other rail fastener components. Typically used to describe the component that is placed between the toe of the rail clip and the rail base top; the rail insulator usually overlaps the rail edge and insulates the rail laterally between the rail and fastener shoulders or other lateral restraint protuberances.

rail, jointed: Rails joined together by means of joint bars and bolts, usually composed of individual rails.

rail rapid transit system: An electrified fixed-guideway transportation system, using steel rails, usually operating on an exclusive grade-separated right-of-way for the mass movement of passengers within a city or a metropolitan area and consisting of its fixed-way, transit car vehicles and other rolling stock, power system, maintenance facilities, and other stationary and movable apparatus and equipment and its operating practices and personnel.

rail contact, resistance: The contact rail’s electrical resistance to ground, measured in ohms per track length (usually the unit for track length is 1000 track feet).

rail, restraining: Rail added to the inside running rail on curves to reduce the possibility of derailments attributed to the leading outside wheel climbing the outside rail and to reduce outside rail wear. Sometimes referred to as guardrail.

rail, running: Rail that supports and guides the flanged wheels of the rail vehicle.



rail seat: The portion of the supporting fastener (fastener body, tie pad, tie plate) that is in direct contact with the bottom of the rail base. The context of this term's usage can refer to the area below the fastener that is within the footprint of the rail base, such as the fastener bearing surface of the concrete slab within the rail seat area.

rail section: The shape of the cross-section of a rail at right angles to its length.

rail, shop welded: Rail pressure butt-welded into continuous lengths by means of electric flash welding, using special machines to align and hold the rail during the welding process.

rail, standard contact: An electrical conductor mode of a steel rail section mounted adjacent to the running rail for supplying DC traction power to the transit vehicles, sometimes referred to as the "third rail."

rail stop: A steel plate welded to a special plate to provide lateral restraint to the rail.

RTD MOW: The organization or portion of an organization that operates rail transit service and related activities. Also called the operating agency, operating authority, transit agency, transit authority or transit system.

railbound manganese steel: A frog consisting essentially of a single manganese steel body casting fitted into and between rolled rails and held together with bolts.

resilient fastener: A fastener, often used in direct fixation track construction, that uses an elastomer between the rail and the support of the fastener.

retaining wall section: A portion of track roadbed elevated or depressed from the surrounding area and located between retaining walls.

right-of-way: Lands or rights used or held for operation.

rigid rail clip: A rail clip design that does not deflect under load; an inelastic rail clip. Rigid rail clips are typically cast steel or iron blocks held by a bolt to a support base or plate. The block bottom face has locking serrations that engage mirror serrations in the surface of the support base or plate. Also called a rigid clamp or rigid rail clamp.

roadbed: The earth bed that supports the ballast, ties and rail of a track structure.

runoff: That part of the precipitation that is carried off from the land upon which it falls. Also refers to the transition zone in lifting track, between track that has been raised and track that has not been raised.

section, dead: A section of track, either within a track circuit or between two track circuits, the rails of which are not part of a track circuit.

semaphore: A signal in which day indications are given by the position of a movable arm.

shatter cracks: Minute cracks in the interior of railheads, seldom closer than ½ in. from the surface, and visible only after deep etching or at high magnification. They may extend in any direction. They are caused by rapid (air) cooling and may be prevented from forming by control-cooling the rail. Shatter cracks also occur in other steel products.



shim: A small piece of wood or metal placed between two members of a structure, or between the rail fastener and its support, to bring them to a desired relative elevation.

shoe: A cast steel or elastomer (or combination of steel and elastomer) component between the top of the rail base and an elastic rail clip. The shoe shape conforms to the rail base top and side, with interlocking shapes (dogs) to the fastener body, shoulder or plate design. See also rail insulator.

shoulder: That portion of the ballast between the end of the tie and the toe of the ballast slope.

shunt: A by-path in an electrical circuit.

siding: A track auxiliary to the main track for meeting, passing or storing trains.

slip switch: 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.

solid manganese steel: A frog consisting essentially of a single manganese steel casting.

solid manganese steel crossing: A crossing in which the frogs are of the solid manganese steel type.

spiral (when used with respect to track): A form of easement or transition curve in which the change of curvature is proportional to its length.

split web: A longitudinal or diagonal transverse crack in the web of a rail.

spot board: A sighting board placed above and across the track at the proposed height, to indicate the new surface and to ensure its uniformity.

spring: In a switch, the operating mechanism incorporating a spring device so arranged as to automatically return the points to their original or normal position after they have been thrown over by the flanges of the trailing wheels passing along the other track from that for which points are set for facing movements.

spring clamp: See *elastic rail clip*.

spring rate: Equivalent to stiffness.

spring switch: A track switch equipped with a spring mechanism arranged to restore points to normal position after having been trailed through.

spring-rail, right-hand and left.-hand: Starting at the toe end of a spring-rail frog and looking toward its point, a right-hand frog has the movable wing rail located on the right-hand side, and a left.-hand frog has the movable wing rail located on the left.-hand side.

stand: A device for manual operation of switches.

standard times: The average times required to perform a given maintenance or operations task. These times are usually estimated originally and constantly refined to reflect experience and progress. They are a measure of production and most useful in estimating personnel, material and budget requirements, as well as for cost control.

station: A place designated for the purpose of loading and unloading passengers.



station, above ground: A station in which the track and platform are either located on an aerial structure or rest directly on grade.

station, underground: A station in which the major portion of the structure is located below the finished grade subway station.

stinger: An electrical device, usually on an overhead trolley used for applying traction power to vehicles in a shop for testing or moving these vehicles. Some shops use external means of moving vehicles, such as locomotives, track mobiles or hi-rail vehicles.

stock rail: The rail against which the point of a switch, derail, expansion joint or movable point frog rests.

sub-ballast: A granular material, superior to most subgrade materials, that is spread on the finished subgrade before top ballast is applied, to provide drainage, to prevent frost heaving and to distribute the load over the top of the subgrade.

sub-drain: A covered drain below the roadbed or ground surface, receiving water along its length through perforations or joints, for the control and removal of excess water.

subgrade: The finished roadbed surface upon which are laid the ballast and the track structure. superelevation (of curves): The vertical distance that the outer rail is above the inner rail. switch: A track device used to divert rolling stock from one track to another.

switch and lock movement: A device, the operation of which performs the functions of unlocking, operating and locking a switch, movable point frog or derail.

switch, electro-pneumatic: A track switch operated by an electro-pneumatic switch and lock movement.

switch, facing point: A track switch, the points of which face toward traffic approaching. switch, hand-throw: A non-interlocked switch that can only be operated manually.

switch, indicator: Device on switch stand or machine in non-signalized territory that indicates the relative position of the switch points.

switch, interlocked: A track switch within the interlocking limits, the control of which is interlocked with other functions of the interlocking.

switch, point: A movable tapered track rail, the point of which is designed to fit against the stock rail.

switch position, normal: The position of a track switch and its controls when opposite to the defining track layout.

switch position, reverse: The position of a track switch and its controls when opposite to the defining track layout.

switch rod: A rod that connects two switch rails.

switch, track: A pair of switch points with their fastenings and operating rods providing the means for establishing a route from one track to another.

switch, trailing point: See *trailing point switch*.



tangent: The straight portion of railway alignment.

test track: A length of track usually separated from a main line, or of sufficient length to safely operate a car or train through a performance cycle (start, accelerate, run at maximum speed, decelerate, stop). The track is equipped with all the system safety features and, in addition, with automatic train control, if the operation is automatic.

third rail: A conductor rail mounted on insulators alongside the running rail that provides traction power for train operation.

third rail shoe: A truck-mounted power pickup device, which slides on top of, on the side of or under the third rail.

thread: The top surface of the head of a rail that contacts the wheels.

threaded fastener system: See *bolted fastener system*.

throat: That portion of a yard that connects the storage areas to the mainline lead tracks or, in an automatic system, to the transfer zone.

throw: The distance through which the switch points are moved laterally, measured at the No. 1 switch rod.

tie, contact rail: The transverse member of the track structure that functions as a crosstie, but is longer and supports the contact rail.

tie, crosstie: The transverse member of a track structure to which the running rails are fastened, which is centered on the track and designed to cushion, distribute and transmit the stresses of traffic from the rail to the ballast.

tie, switch: The transverse member of a track structure that functions as a crosstie, but is longer and supports a crossover or turnout.

toe: The end of a frog nearest the switch point.

toe length: The distance between the ½ in. point of a frog and the toe, measured along the gage lines.

toe load: The clamping load generated by an elastic rail clip on a rail base.

toe spread: The distance between gage lines at the toe.

tolerance: An allowable variation from dimensions or requirements specified.

track, ballasted: Track constructed of rail, ties and ballast.

track, direct fixation (DF): Track constructed of rail and direct fixation rail fasteners attached by means of anchor bolts to a concrete slab a plinth or a steel surface.

track layout: An organized assemblage of track; the depiction thereof for control purposes.

track, main: A track extending through yards and between stations, upon which trains are operated by timetable or train order or both, or the use of which is governed by signals.

track, main line: A track designated by route name and direction for the purpose of carrying revenue passengers.

track mobile: A self-powered road-rail vehicle.

track relay: A relay receiving all or part of its operating energy through conductors, of which the track rails are an essential part.



track, reversible: A section of track on which the prescribed direction of running can be reversed if it is unoccupied and the opposing home signal is at stop.

track, single: A main track on which trains are operated in both directions.

track switch: See *switch, track*.

track, transfer: A track in a yard area where the transfer between main track and manual yard modes or operation takes place.

track, yard and secondary: Track constructed for the purpose of switching, storing or maintaining rail vehicles and not used for carrying revenue passengers.

trailing movement: The movement of a train from the frog toward the point of switch. trailing point switch: A track switch, the points of which face away from traffic approaching. train orders: Instructions used to govern trains manually, usually written and hand-delivered.

transverse defect: For defects found by detector cars, a tentative group classification, applied prior to the breaking of the rails, of all types of rail defects that have transverse components, such as transverse fissures, compound fissures and detail fractures.

transverse fissure: A progressive crosswise fracture starting from a crystalline center or nucleus inside the head, from which it spreads outward as a smooth, light 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.

trolley wire: See *catenary*.

truck: A major transit vehicle assembly of structural members, wheels and axles, motors, gearboxes, brakes, collectors, cable, piping, etc.

turnout: An arrangement of a switch and a frog, together with closure rails, by means of which rolling stock may be diverted from one track to another.

turnout number: The number corresponding to the number of the frog used in the turnout.

unbonded fastener: A resilient fastener where the elastomeric material is not bonded to a steel top plate or a steel bottom plate. See also *bonded fastener*.

unsafe condition: Any condition that endangers human life or property.

vertical split head: A split along or near the middle of the head of a rail and extending into or through it. A crack or rush streak may show under the head close to the web, or pieces may be split off the side of the head.



vertical stiffness (elastomeric fasteners):

The stiffness of an elastomeric fastener from loads and deflections measured in the rail's vertical axis. If not stated explicitly otherwise, this stiffness value is measured with no rail cant.

water pocket: A depression in the roadbed, filled with ballast or other porous material, wherein water collects, to the detriment of track stability. Also described as a "ballast pocket."

water table: The underground water level.

width: The distance between the gage line and the guard line of a track structure, which provides a passageway for wheel flanges.

work train: A train composed of work cars pulled by a prime mover, generally a locomotive.

wye (y): A track or guideway arrangement allowing a car or train to be turned by a series of moves; requires much yard space.

yard: A system of tracks within defined limits provided for making up trains, storing cars and other purposes over which movements not authorized by timetable or by train order may be made, subject to prescribed signals and rules or special instructions.

yard: A system of tracks within defined limits for making up trains and storing cars.

yard master: A Transportation Department employee, generally the supervisor for a yard's transportation activity.

yard speed: The safe operating speed of railway vehicles over yard trackage.

zero longitudinal restraint (ZLR) systems:

A special category of direct fixation fastener that is designed to have zero longitudinal restraint. In general, zero restraint is achieved by placing a formed rigid steel plate between the rail clip and the top of the rail base such that there is no contact with the top of the rail base. This device is generally used for long bridges and requires the installation of rail expansion joints at or near the bridge structural expansion joints. Zero longitudinal restraint systems are virtually all-resilient fasteners but may be of other designs under this definition.

zero thermal stress temperature: The temperature at which a string of continuous welded rail that has been restrained will not be stressed due to thermal expansion or contraction.

Abbreviations and acronyms





Abbreviations and acronyms

AREMA	American Railway Engineering and Maintenance-of-Way Association
ATC	automatic train control
CWR	continuous welded rail
DC	direct current
DF	direct fixation
DRT	desired rail temperature
Ht	highest rail temperature
Lt	lowest rail temperature
NATSA	North American Transit Services Association
NRT	neutral rail temperature
OEM	original equipment manufacturer
OTM	other track material
PPE	personal protective equipment
PRLT	preferred rail-laying temperature
SJ	standard joint
ZLR	zero longitudinal restraint

Summary of document changes and history





Summary of document changes

N/A

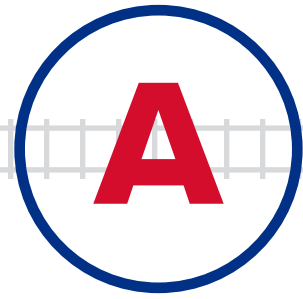
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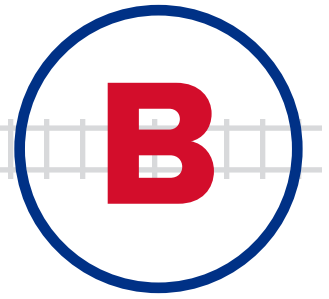


Appendix A: Track surface table

Table A1 is a guideline for maximum allowable speeds based on individual track geometry parameter deviations.

TABLE A1
Maximum Allowable Speeds on Various Track Conditions

Max. Allowable Speed	Parameter							
	62 ft. Twist, Spirals	31 ft. Twist, Spirals	62 ft. Twist, Curves and Tangent	31 ft. Twist, Curves and Tangent	Crosslevel	62 ft. Surface	31 ft. Surface	31 ft. Runoff
Class 1 Track								
15	3 in.	2 in.	3 in.	1½ in.	3 in.	3 in.	⅞ in.	3½ in.
Class 2 Track								
20	2¾ in.	1⅞ in.	2¾ in.	1⅜ in.	2⅝ in.	2⅞ in.	⅞ in.	3⅜ in.
25	2½ in.	1⅞ in.	2½ in.	1¼ in.	2⅜ in.	2⅞ in.	¾ in.	3⅞ in.
30	2¼ in.	1¾ in.	2¼ in.	1⅞ in.	2 in.	2¾ in.	¾ in.	3 in.
Class 3 Track								
35	2¼ in.	1⅝ in.	2¼ in.	1⅞ in.	2 in.	2⅝ in.	¾ in.	2⅞ in.
40	2⅞ in.	1⅝ in.	2⅞ in.	1⅞ in.	1⅞ in.	2⅝ in.	⅝ in.	2⅝ in.
45	2⅞ in.	1½ in.	2⅞ in.	1⅞ in.	1⅞ in.	2½ in.	⅝ in.	2½ in.
50	2⅞ in.	1⅜ in.	2⅞ in.	1 in.	1⅞ in.	2⅜ in.	⅝ in.	2⅜ in.
55	2 in.	1⅜ in.	2 in.	1 in.	1¾ in.	2⅜ in.	½ in.	2⅞ in.



Appendix B: Continuous welded rail (CWR) practices

This appendix provides practices for RTD MOWs that maintain continuous welded rail (CWR) track.

B.1 CWR

Continuous welded rail is defined herein as any continuous rail 400 ft. or more in length.

B.1.1 Thermal expansion

Nearly all materials, including rail, expand and contract with temperature changes. When the temperature of the rail increases, the rail attempts to grow in length, and when the temperature of the rail decreases, the rail attempts to shorten. If rail is free to change length with changes in rail temperature, then it will behave in a predictable manner.



B.1.1.1 Formula for expansion of unrestrained rail

The amount that unrestrained rail will expand, or contract can be determined with the following formula:

$$\Delta RL = RL \times \Delta T \times 0.000078,$$

where

ΔRL = change in rail length (in inches) RL = unrestrained rail length (in feet)

ΔT = change in rail temperature (in Fahrenheit degrees). The change in rail temperature from when it was originally measured.

0.000078 = coefficient of expansion for steel rail

$$\Delta RL = RL \times 12 \times \Delta T \times 0.0000065,$$

where:

ΔRL = change in rail length (in inches) RL = unrestrained rail length (in feet)

12 = conversion of rail length from feet to inches

ΔT = change in rail temperature (in Fahrenheit degrees). The change in rail temperature from when it was originally measured.

0.0000065 = coefficient of expansion for steel rail

The effect that temperature has on unrestrained rail length is shown in **Table B1**.



TABLE B1
Longitudinal Rail Expansion vs. Temperature Change

ΔT Change in Rail Temperature	Rail Length				
	100 ft.	1320 ft.	2640 ft.	3960 ft.	5280 ft.
10 °F	1/16 in.	1 in.	2 1/16 in.	3 1/16 in.	4 1/8 in.
20 °F	1/8 in.	2 1/16 in.	4 1/8 in.	6 3/16 in.	8 1/4 in.
30 °F	1/4 in.	3 1/16 in.	6 3/16 in.	9 1/4 in.	1 ft., 3/8 in.
40 °F	5/16 in.	4 1/8 in.	8 1/4 in.	1 ft., 3/8 in.	1 ft., 4 7/16 in.
50 °F	3/8 in.	5 1/8 in.	10 5/16 in.	1 ft., 3 7/16 in.	1 ft., 8 9/16 in.
60 °F	7/16 in.	6 3/16 in.	1 ft., 3/8 in.	1 ft. 6 1/2 in.	2 ft., 3/4 in.
70 °F	9/16 in.	7 1/4 in.	1 ft., 2 7/16 in.	1 ft., 9 5/8 in.	2 ft., 4 13/16 in.
80 °F	5/8 in.	8 1/4 in.	1 ft., 4 7/16 in.	2 ft., 3/4 in.	2 ft., 8 15/16 in.
90 °F	1 1/16 in.	9 1/4 in.	1 ft., 6 1/2 in.	2 ft., 3 13/16 in.	3 ft., 1 1/16 in.
100 °F	3/4 in.	10 1/4 in.	1 ft., 8 9/16 in.	2 ft., 6 7/8 in.	3 ft., 5 3/16 in.

B.1.1.2 Rail size and amount of rail movement

The size or weight of the rail has no effect on the amount that the rail will expand or contract. Only the unrestrained length of the rail affects rail movement. For a given change in rail temperature, the amount of expansion and contraction is the same on 60 lbs./yd. or 136 lbs./yd. rail sections.

B.1.1.3 Longitudinal rail stresses from temperature changes

CWR attempts to change rail length with changes in temperature. Rail is installed such that this expansion and contraction

cannot occur; hence large stresses can build up along the rail, and these forces are called longitudinal forces.

There are three force states for rail installed in track: compression, tension and neutral. When the temperature of the rail increases, the rail attempts to grow in length. This is prevented, so the rail pushes against itself, creating compressive forces. When the temperature decreases, the rail attempts to shorten itself. Again, this is prevented, and the rail pulls against itself, creating tension forces. When the rail temperature is equal to that where no expansion or contraction will occur, the rail is at “neutral” temperature. Since rail has only one temperature at which it is at “neutral,” odds are that some longitudinal forces do exist.



While size or weight does not affect the amount that rail expands or contracts, it does affect the forces generated. The larger the rail size, the greater the force generated with a temperature change. The forces can be calculated using the following formula:

$$\Delta LF = RW \times \Delta T \times 19.015,$$

where:

ΔLF = longitudinal force (in pounds) RW = rail weight (in pounds per yard)

ΔT = change in rail temperature (in degrees Fahrenheit)

19.015 = constant derived from Young's modulus (29.85×10^6 psi) \times Coefficient Expansion of Steel (6.5×10^{-6} °F⁻¹) \times Ratio of Rail Cross-Section to Weight per Yard (0.098)

The effect that rail size has on these longitudinal rail forces is shown in **Table B2**.

TABLE B2

Longitudinal Rail Forces vs. Temperature Change (in pounds)

ΔT Change in Temperature	Rail Size (rail weight, in pounds per yard)				
	60	90	100	115	136
0 °F	0	0	0	0	0
25 °F	28,523	42,784	47,538	54,668	64,651
50 °F	57,045	85,568	95,075	109,336	129,302
75 °F	85,568	128,351	142,613	164,004	193,953
100 °F	114,090	171,135	190,150	218,673	258,604

B.1.1.4 Longitudinal rail stresses from train traffic

In addition to the longitudinal stresses induced by changes in rail temperature, train traffic can generate large longitudinal forces. When trains accelerate or brake, the momentum of the train is translated into longitudinal forces in the rail. These forces can be very high. For RTD MOWs, the effects of these forces can be compounded, since train stops and starts occurring

nearly at the same locations, in the same directions with every train. Locations such as stations, street crossings, speed changes and interlockings are particularly impacted. Automatic train control (ATC) systems further exacerbate these effects, since the system will automatically brake and accelerate all trains at exactly the same locations every time; whereas with manually controlled trains each train operator will brake/accelerate trains at slightly different locations and rates. While the adverse



effects of, for example, a station stop, will still be present with or without an ATC system, the ATC system could make these effects more prominent.

B.2 Longitudinal rail restraint

This section discusses the large forces that can be generated in CWR. When CWR is installed in the track, these forces are offset with four restraints: tie plate/rail seat friction, joint bar restraint, fastening system, and the ballast cross-section and condition.

The friction from tie plates is negligible and can be discounted for practical purposes.

At properly maintained rail joints, the longitudinal restraint of the rail is approximately equal to the clamping force of each bolt. A properly torqued bolt provides about 25,000 lbs. of restraining force. For a rail joint with four bolts installed, this equates to 100,000 lbs. of restraining force per joint, 150,000 lbs. for six-hole joint bars. Note that this is for a “properly maintained” rail joint. Loose rail joints do not provide as much restraint as is possible.

The fastening system provides the primary resistance to longitudinal rail forces and movement. The cut spike/rail anchor fastening system can provide significant longitudinal restraint, if properly maintained. Loose or missing rail anchors can greatly reduce restraining capacity. With many resilient fasteners, the rail alignment and longitudinal restraint are combined, such that no rail anchors are required. The vertical restraint capacity of a well-maintained elastic fastening system is approximately 5000 lbs. per rail seat.

Direct fixation (DF) fastening systems can provide significantly large restraining forces. This is also true of street-running track where the rail is somewhat shielded from the sun’s energy, in addition to providing large restraining forces. Great care shall be taken not to rely solely on these additional restraining forces. Rail should be maintained at proper thermal adjustment, regardless of the type of track construction. Sudden failure of the fastening systems can occur if the rail is not properly adjusted. The high forces will also be transferred to the structure, causing permanent damage. Sun kinks and pull-aparts can also occur on these track forms, and the results usually take more resources to repair, with

symptoms such as loss of gage and failed DF fasteners; on street-running track the rail can lift. out of the roadway.

On ballasted track, the longitudinal forces from the thermal rail expansion and contraction are transmitted from the rail fastening system to the ties. The ties then transmit these loads to the ballast. Well-maintained ballast with well-maintained fastening systems provide approximately 1300 lbs. of resistive longitudinal force per anchored tie. This can be significantly reduced if there is insufficient ballast, if the ballast is not well- consolidated, if ballast with poor interlocking properties is used, or if the track is not firmly tamped. The resistance of ballast to lateral movement is broken down by approximately 40 percent provided by the bottoms of the tie, 40 percent by the ballast cribs, and 20 percent by the ballast shoulders. Frozen or dry ballast fouled with dirt can increase the restraining capacity of ties; however, this restraint capacity is not to be relied upon.




In the case of frozen ballast, it can quickly thaw; with dirty ballast, a rain can cause a significant loss of restraint.

In some cases, CWR is purposely installed with no longitudinal restraint. This is done to prevent the large forces generated in the rail by temperature changes from transferring to bridges or other similar structures. In these circumstances, special “slip joints” are installed in the track to allow the rail to freely expand and contract. These slip joints are also installed at approaches to moveable bridges to ensure that any rail movement does not adversely affect the operation of the bridge.

B.3 Determining rail temperatures

Even on short corridors, the tracks can pass through numerous microclimates; separate calculations should be made for each region where CWR is used. Even if the climate is uniform throughout RTD MOW’s property, consideration should be given to different track forms, such as at-grade, elevated (aerial) and subway; the rail temperatures can vary considerably along these different types of track. For example, a bridge over a river or raised trackway that is subjected to a constant breeze may react differently from ballasted track in a cut in the same area. Knowledge and familiarity with local weather patterns and what effects they have on the track should be used when dividing temperature range for each of these geographic areas in which the CWR is located.



CWR should be laid when the rail temperature is within the temperature range specified by the following equations. See **Table B5**.

$$\text{DRTMIN} = ([2\text{Ht} + \text{Lt}] / 3) + 10 \quad \text{DRTMAX} = ([2\text{Ht} + \text{Lt}] / 3) + 25 \pm 5,$$

where:

DRTMIN = minimum desired rail temperature, degrees Fahrenheit; DRTMAX = maximum desired rail temperature, degrees Fahrenheit; Ht = highest recorded rail temperature, degrees Fahrenheit

Lt = lowest recorded rail temperature, degrees Fahrenheit.

Rail temperature is not directly related to ambient or air temperature. At night, or when there are heavy clouds, the rail temperature closely follows the ambient temperature. However, the rail temperature will lag the ambient, since it takes time for the rail temperature to change; the faster the ambient temperature changes, the greater the lag in the rail temperature. This is also true for rail size. The larger the rail size, the greater the lag, since it takes more time for a given amount of thermal energy to heat up a larger mass of rail. When the rail is in direct sunlight, its temperature can significantly increase over the ambient. It is not unusual for the rail temperature to be as much as 40 °F or higher than ambient when it is in direct sunlight.

Two calculations should be made for each geographic region, one for a minimum and one for the maximum. As can be seen, the “DRTMAX” formula includes a plus or minus 5 °F. Which end of the range is appropriate for each RTD MOW should be determined by experience. If a system experiences extremely low rail temperatures in winter and high temperatures in summer, it may be appropriate to use the minus 5 °F, whereas if the temperatures are more temperate or high temperature spikes are common, then

the plus 5 °F may be appropriate. Again, the experience of railroad qualified personnel should be relied upon.

The minimum and maximum temperatures to be used in these formulas can be easily obtained from various sources. Many university libraries have books showing historical weather data; this information can sometimes be obtained on the internet. Other excellent sources are government weather agencies. If research time is unavailable, then this data can be obtained, for a fee, from professional weather services. Historical weather data will be for ambient. While the ambient temperature can be used for the minimum rail temperature, the maximum historical ambient temperature should be increased to that experienced by an RTD MOW. Experience should be used in determining the maximum possible rail temperature.

Once the DRTMIN and DRTMAX (minimum and maximum) rail temperatures are determined for each geographic area, the preferred rail-laying temperature (PRLT) can be determined. The PRLT should be within the range provided by the DRTMIN and DRTMAX. Again, experience should be used; however, it is far better to err on the



high side than low, as a sun kink could be far more dangerous than a rail pull-apart. A pull-apart will typically show up as a false occupancy in the signal circuit, while a sun kink is typically found by a train, and many times can occur under a train. With the PRLT determined, it is not unusual for a RTD MOW to provide a plus and minus range of a few degrees. This allows maintenance personnel a range to work within, without having to expend excessive resources. This range should be a few degrees only, not so large as to allow sloppy workmanship.

When making the PRLT determination, it is advisable for RTD MOWs to be aware that the neutral rail temperature (NRT) changes over time. The NRT differs from the PRLT. The PRLT is the temperature that rail is installed at or adjusted to when rail is thermally adjusted. The NRT is the actual adjusted temperature of the rail. This tends downward from the PRLT due to maintenance activities and rail creep. The longer the rail has been installed, the lower the NRT tends to be. It is better to err to the higher temperature when making the determinations as to what the PRLT should be, with experience being the guide.

B.4 Maintenance activities on CWR track

If the track is disturbed when the rail temperature is above or below the NRT, then the track can become unstable. By disturbing the tracks, resistance to longitudinal rail movement and lateral restraint can be significantly diminished. It is important to keep in mind that problems can be encountered when disturbing the track at temperatures below the NRT. So much emphasis is placed upon dealing with CWR track in hot weather that cold-weather problems are often ignored. CWR track can be easily and safely disturbed within median temperature ranges. Precautions need to be taken only when it is disturbed at temperatures above or below this range.

The following maintenance activities are examples of work that would constitute disturbing CWR track:

- undercutting track
- tie replacement
- track surfacing and alignment
- field welding rail
- track gaging
- replacement of rail fasteners or rail anchors
- track or switch panel installation
- track shimming
- disturbing the ballast section

These are common maintenance activities and do not exclude additional activities that could disturb the track.



B.4.3 Maintenance operations that disturb track structure

The following maintenance work on CWR track should be performed when the rail temperature is equal to or lower than the installation or latest adjusted rail temperature:

- out-of-face track raising and lining
- rail renewal
- tie renewals (with or without raising)
- disturbing the ballast section

B.5 Surfacing and aligning CWR track

B.5.1 General

When surfacing and aligning CWR track, there should be sufficient ballast prior to surfacing. When the work is complete, with the cribs and any gaps at the tie ends filled, the ballast section should be completely restored.

B.5.2 Effect of repairing surface and alignment of the track on the neutral temperature of the rail (NRT)

Surfacing and aligning CWR track can greatly affect the NRT. Where the surface of the track is in extremely poor condition, resurfacing will reduce the neutral temperature of the rail. On rough track with surface deviations, the rail covers a longer distance than on smooth track. The worse the track surface and alignment prior to surfacing, the greater the reduction in neutral temperature. Serious consideration should be given to thermally readjusting the rail throughout.

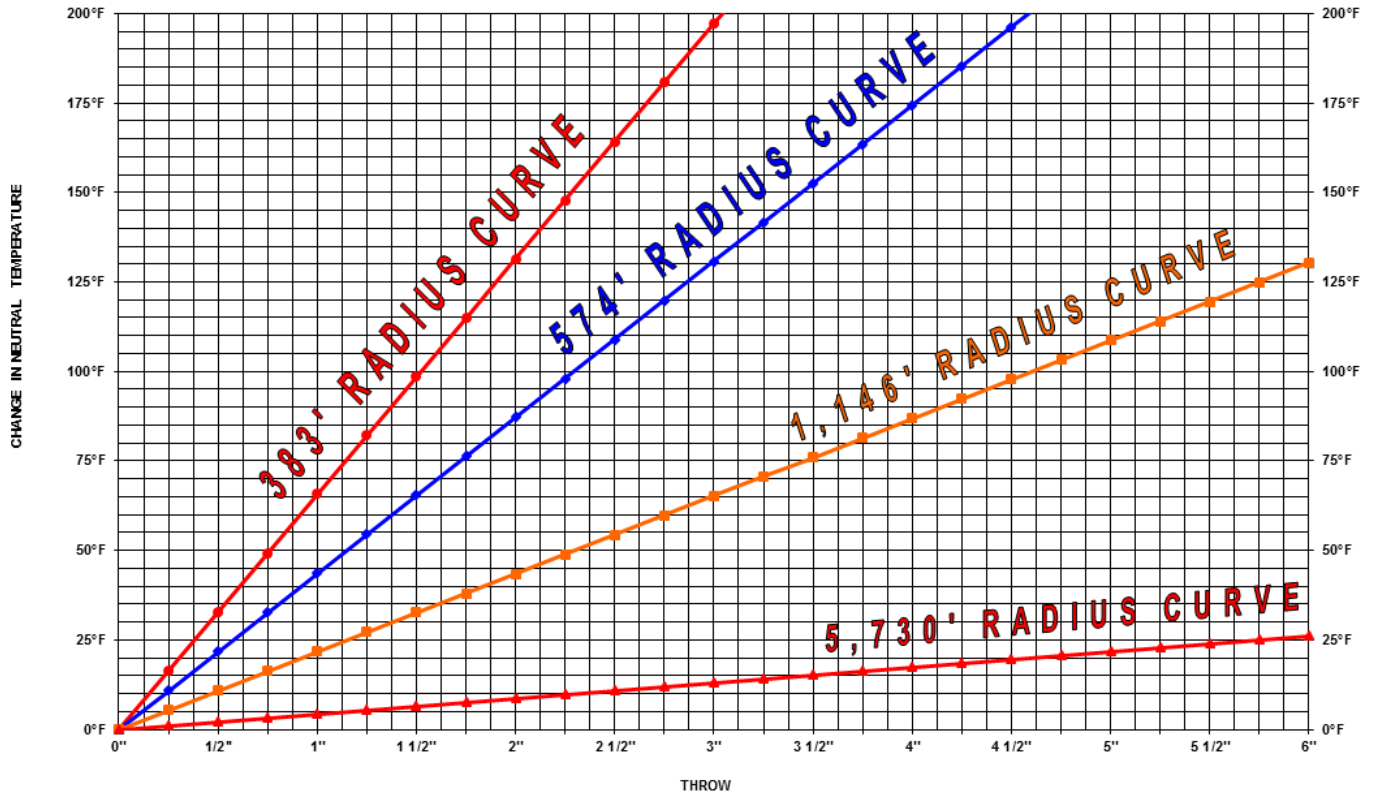
B.5.3 Curve alignment and neutral temperature

When curved track is realigned, the throws should be balanced. For every inch of outward throw, there should be an inch of inward throw. If the curve is thrown outward, the track is made longer, raising the neutral temperature. If thrown inward, the track is then shorter, and the neutral temperature is reduced. Neither of these is desirable. If the neutral temperature is too high, either by incorrect adjustment or by aligning the curve outward, then the track will tend to move inward, usually not uniformly, creating a misalignment “flat spot” in the curve. Where the neutral temperature is too low, through mis adjustment or by aligning the track inward, a sun kink is risked. The sharper or longer a curve, the larger the impact to the neutral temperature. This is illustrated in **Figure B1**, which shows the changes for selected curve radii for curves 100 ft. long.



FIGURE B1

Effects of Throws on Neutral Temperature, 100 ft. Long Curves



When realigning curves, where large throws are required, it is good to consider thermally readjusting the rail in the curve. When the throws are quite large, even if the throws are balanced, localized stretching and bunching of the rail can occur. Large surfacing and

lining machines do help somewhat, since they vibrate the entire track structure, which helps the rail slide through fasteners. On cut spike track, the rail anchors can be removed prior to aligning the track. With resilient fasteners, thermal readjustment may be the only option.



B.6 CWR special inspection

B.6.1 Why special inspections are performed

With extremes in ambient temperatures, special inspections should be made on CWR track. While hot weather typically provides a greater risk for sun kinks, extremely cold weather can also create problems on CWR with pull-aparts.

The neutral or force-free temperature of the rail tends to reduce with time. Since the rail temperature is usually artificially increased during installation and maintenance, any disturbance without readjustment will cause the neutral temperature to decrease. Since there is no easy way to determine the neutral temperature of CWR, inspection of CWR track is critical to ensure uninterrupted train operations.

Inspections for potential problems in CWR track should not be limited to extremes in weather; there are many indicators of unstable track that are evident to diligent inspectors. These indicators should be watched for during regular track inspections, so problems can be identified in advance of failure or weather extremes and repairs can be made on a programmed basis.

B.6.2 Methods of performing special inspections


Special inspections on CWR during temperature extremes can be made using the normal methods used for regular track inspections. One of the hardships of maintenance personnel in RTD MOWs is the restriction to track access due to the high frequency of trains. Frequent trains can be

beneficial for special inspections. Personnel making special inspections can cover large territories in a short time by riding the trains. The person making the inspection should ride in the trailing or leading end of the train, positioned where he or she has full view of the track. If possible, the trailing end of the trains is preferred, so the person performing the inspection will not interfere with those operating the train. Even though the train may be traveling at high speeds, many of the indicators of a pending or potential problem can be readily identified. If necessary, a more detailed visual inspection can be made. It is not unusual for personnel performing special inspections to make multiple passes over the same track. This allows maintainers persons performing inspections to see if changes have occurred or if problems have developed since the last pass.

During temperature extremes, control is a good resource for information concerning adverse effects of temperature extremes. Problems such as false occupancies in CWR track with track circuits and problems with the operations of switches and movable bridges should be investigated. Patterns and repeated complaints are excellent indicators of pending problems. Good communication with personnel who are operating the trains is an excellent tool for determining where to take a closer look for potential problems.

B.6.3 When special inspections should be performed

Special inspections of CWR will be conducted when ambient air temperature exceeds 100 degrees.



B.6.4 Items to watch for during special inspections of CWR

The following are examples of items that should be watched for when special inspections are made on CWR during temperature extremes. Persons performing regular track inspections should also be vigilant for these same conditions during regular track inspections.

Rail

- canting or tipping of the rail
- the rail crowding the shoulders of fastening systems
- rail lifting or riding up in tie plates and rail fasteners
- scrape marks on the rail indicating longitudinal rail movement
- uneven wear patterns on the rail gage face or running surface
- excessive longitudinal rail movement at slip joints, switch points and stock rails
- misaligned switch points

Rail joints

- pull-aparts
- track bolts that are bent, broken or worn
- heavily worn fishing surfaces
- frozen joints (rail end gaps at rail joints that are open when the rail is hot and closed when the rail is cold)

Rail fasteners

- tearing, lifting or separating of direct fixation fasteners
- missing rail anchors
- rail anchors that are away from the edge of the tie
- lifted spikes
- resilient fasteners that are loose, missing or broken along one side of the rail
- skewed gage rods

Ties

- skewed ties
- tie movement or bunching (uneven tie spacing)
- hanging or swinging ties, particularly at approaches to bridges or direct fixation track
- clusters of defective ties

Track geometry

- misalignment, kinks, buckles in the track, in particular at fixed objects such as road crossings, bridge or subway approaches, and special track work
- changes in alignment with temperature changes
- irregular gage
- pumping track (excessive up-and-down movement under load)



Ballast

- churned (freshly disturbed) ballast
- displaced ballast
- gaps in the ballast at the end or sides of the ties
- bunched up or piled ballast at the end or sides of the ties
- insufficient ballast shoulder

Other areas

- track that has been recently worked on
- new track
- past derailment locations
- past washout locations
- steep grades
- locations subjected to heavy acceleration and braking (stations, speed changes, interlockings) locations with soft. subgrades and drainage problems



CWR Remedial Action Needed

The following “Remedial Action Table” may be used as a guide to determine appropriate action to take when indications of track under high thermal forces have been found.

Remedial Action Table

Sub-standard Item Detected	Repair Required
RAIL	
Rail tilting on tie plates	De-stress
Crowding the shoulder of the tie plates on curves	De-stress (can be a normal condition), additional information needed
Riding up or out of the tie plates	De-stress
Marks on the base of the rail where the rail is moving through the spikes	De-stress (check anchor condition)
Uneven wear on the rail surface, or welds, under traffic	Determine cause and correct
Poor weld alignment	Replace weld, check for track movement
Severe corrugation in curves	Remove corrugation, check for rail run
Longitudinal movement of switch point to the stock rail	De-stress both sides of turn out as needed
JOIN AREAS	
Bars: broken, bent, cracked	Replace
Not fully bolted or bolts that are loose	Fully bolt, check bolt condition, tighten and/or replace as necessary
Bolts: Missing, bent	Replace
Battered rail ends	Slot, weld or replace
Mismatched rail ends	Weld, compromise, or replace
Gap between tie plate and rail	Nip up and tamp joint ties
Not closed 40° F above PRLT	Check drilling, bent bolts, frozen joint distress
Missing/broken/flattened insulating post (insulated joint)	Replace post (armored) or replace joint (glued)
Missing/broken rail fasteners	Check for rail run, replace fastener
Cracked/shattered epoxy on glued joints	Check integrity (bars, bolts, insulation, electrical resistance), and compromised, replace
Pull-aparts	Repair as outlined in Maintenance Standards
Frozen (standard or compromise) joints	Oil and check bolt condition
Location where rail repairs were made in the winter	Check to see if de-stressing is required or eliminate joint

Remedial Action Table (continued)

Sub-standard Item Detected	Repair Required
Joint elimination areas that may have had rail added	Check to see if de-stressing is required
Missing/broken washers	Replace
More than one washer or nut	Check bolt size and replace with proper size, complete with one washer and one nut only
Improper torque	Check bolt condition and re-torque
Disturbed ballast, and/or surface deviation, and/or displaced rail anchors	Check for excessive rail movement at joint bar (fishing surface), tighten bolts/replace joint, tamp up joint ties and adjust anchors
FASTENINGS	
Spikes: high, missing, bent	Plug and re-spike, if condition persists, de-stress as needed
Improper pattern of spikes	Re-spike to RTS specifications
Anchors: missing, loose, damaged	Replace, check for rail run
Anchors away from tie or plate	Tighten and check for rail run
Improper pattern of anchors	Re-set to RTS specifications
Elastic fasteners: missing, loose, damaged	Replace, and check for rail run. De-stress as needed
Area of heavy brake application	Check for rail run and install additional anchors as needed
TIES	
Defective	Replace in accordance with RTS specifications
Skewing	Check ballast and anchors. De-stress
Moving and bunching from longitudinal movement	Check ballast and anchors. De-stress
Clusters of poor ties	Never leave more than two adjacent defective ties
Hanging ties	Surface and check for rail run
BALLAST	
Inadequate shoulder	Check cause, de-stress, or slow order until reinstated
Cribs not full, narrow shoulder	Regulate or add ballast, check for rail run. De-stress if needed
Pumping	Undercut, de-stress if needed



Remedial Action Table (continued)

Sub-standard Item Detected	Repair Required
TRACK GEOMETRY	
Misalignment	Slow order to RTS compliance and reline
Lateral or vertical movement when temperature is more than 20° F above the PRLT	Slow order may be required, notify the Track Supervisor, de-stress as needed
Poor Surface	Surface and line, check for rail run
Spike killed ties	Plug and re-spike. Check adequate tie contact with anchor
Anchors on shimmed ties	Remove
Poor cross level	Check cause, slow order to RTS compliance and surface
Gauge irregularities	Re-gauge, check tie condition. If cause is tight rail, may require de-stressing
Blocked ditches or culverts	Repair
Slide/washout areas	Stabilize, de-stress
Where the rail moves under traffic causing ties to skew and bunch up such as wet low lands, poor subgrade, etc	Stabilize, de-stress



B.7 Slow orders/speed restriction on CWR track

While CWR track may be stable and able to withstand thermal expansion and contraction forces, the dynamic loads imposed on the track by trains can reduce the track's ability to maintain alignment. Train braking increases in rail temperature from the friction of the train wheels, and the up-and-down movement of the track that occurs as trains pass all work to degrade the track's ability to maintain stability. The following are some of the dynamic factors that can affect CWR track's ability to remain stable:

1. train speed
2. axle loads (the heavier the axle loads, the worse the effects)
3. train length (longer trains disturb the track more with a cumulative effect; typically the longer the train, the greater the track displacement, and the temperature increase from rolling friction is greater)
4. train frequency
5. sharp curves (the sharper the horizontal curvature, the greater the translation of longitudinal rail forces to lateral track forces)
6. steep grades (the steeper the grade, the greater the effect of train braking and acceleration forces)

With higher train speeds, larger forces are generated from dynamic loading all around. This includes larger track displacement, greater friction-related temperature increases to the rail, and significantly larger longitudinal forces from braking/acceleration


and larger lateral loads on the track from truck hunting and the effects of minor (typically acceptable) geometry deviations.

These dynamic forces alone can increase the risk factors to the stability of the track. These, combined with freshly disturbed track, can lead to even higher risk factors for continued high-speed train operations.

As with other items related to CWR maintenance practices, the need for and the level of speed restrictions should be determined on a case-by-case basis by RTD MOWs. Experience and knowledge of the individual property and types of operations should weigh heavily in the decision-making process. Many look to the policies and procedures of heavy haul freight railroads for examples of what should be done. It should be kept in mind that these policies are based upon experience and research based upon what can be vastly different circumstances, such as heavier and longer trains and less-frequent inspections during temperature extremes. Whatever policy is used, the RTD MOW should weigh all the affecting factors and develop uniform procedures for placing speed restrictions under the following situations:

- extreme high temperatures
- extreme low temperatures
- after maintenance work is performed
- after maintenance work is performed where temperature extremes are expected

It should be noted that different speed-restriction scenarios are required for different maintenance tasks. In some cases, various different types of CWR track maintenance tasks can be lumped together to simplify the process but still provide the



needed safety measures. A clear, easy-to-understand policy may be better than a detailed, complex policy that may be hard for personnel to interpret and apply

RTD MOW may determine that temperature and/or maintenance-related speed restrictions are not needed in subways or on DF track but are on ballasted track.

If it is determined that speed restrictions are required in some circumstances, then what those speeds will be is another factor in the decision-making process. This is in no way inferring that no speed restriction should be placed when one is needed, only that the speeds used should be obtainable.

B.8 Rail temperature measurement

Reliable pyrometers (thermometers) should be used to determine the rail temperature. Numerous styles are available, any of which is sufficient for determining the temperature of the rail.

If mechanical or liquid type rail thermometers are used, then at least two thermometers should be used simultaneously; the average of the temperatures shown on the thermometers should be used for determining the rail temperature. The thermometers should be placed on the shaded side rail web and left there for at least 10 minutes.

When using non-contact infrared or laser type pyrometers, multiple readings should be taken in at least three locations along the rail. The pyrometer should be aimed at a shaded portion of the rail and the reading

taken close enough to the rail to ensure that only the rail temperature, and not that of ballast, ties and fasteners, is measured. Ensure that OEM recommendations and instructions are followed.


The accuracy of rail pyrometers should be occasionally checked and calibrated. An easy method of checking pyrometers is to measure the temperature of an ice water solution, which should provide 32 °F, and that of boiling water (212 °F). While variations in elevation and air pressure will affect these temperatures, this method can provide an easy check between calibrations.

B.9 Thermal rail adjustment methods

Five methods are commonly used for thermally adjusting the rail:

Rail pullers: This method uses powerful hydraulic cylinders that are clamped to the rail, then manually or power operated hydraulic pumps. These types of rail pullers can generate as much as 120 or more tons of pulling power. It should be noted that these rail pullers might not work on rails next to an electric third rail. The size of the pulling unit and third rail clearances should be investigated.

Rail heaters: This method uses equipment that rides along the rail that heats the rail using an exposed flame or infrared heating unit. Propane has historically been used for rail heaters; however, units are available that use diesel fuel, which can be more desirable in some cases due to easier resupply and a lower fire hazard. If not properly used, this method can damage plastic or rubber



components of fastening systems and can set fire to wood ties. These drawbacks can be overcome if the equipment is properly used and if sufficient precautions are taken. It should be noted that because of the possible fire risk, some RTD MOWs are not allowed to take propane or large amounts of flammable gases and fuels into subway areas. Heating the rail using electrical heaters has also been explored.

Burn ropes: This method uses diesel fuel-soaked ropes that are stretched out along the rail base and then lit. The resultant heat from the wicking off of the fuel heats the rail. Before these are used, it would be wise to discuss their use with fire protection agencies that have jurisdiction. Many times when these are used, concerned citizens will call emergency personnel when they see the smoke and fire. Prior coordination with local emergency agencies and advance notification immediately prior to use is one method of preventing problems. A modified version of this method is available that uses a smokeless chemical process that does not have an open flame.

Natural air temperature: This method relies upon the effects of the air temperature to heat or cool the rail. This method can be somewhat inconvenient, since work must be scheduled depending on the weather. When the rail temperature is too low to perform work such as repair of a pull-apart or a rail renewal, the rail will have to be readjusted at a later date. Great care should be taken so the locations that require readjustment are promptly readjusted. The risk is that a hot weather spell could occur before the locations are readjusted. Good record-keeping and communication are the keys to preventing impacts to train operations.

Speed restrictions and/or track outages may be necessary when early heat spells occur. Special care shall be taken to protect these areas during hot weather. The greatest problem with this method is that major impacts to train operations will eventually occur, in addition to the additional resources required for readjustment.

Water spray: This method is used exclusively for cooling the rail; it relies upon water sprayed on the rail. The rail is typically cooled using both the heat transfer from the rail, which is typically warmer than ambient, and the evaporative energy of the water sprayed on the rail. Using refrigerated water or ice water can speed up this process.

B.10 Practical CWR maintenance applications

The following are some recommended methods for dealing with specific common CWR maintenance tasks. These are provided only as examples to guide RTD MOWs. It is acceptable for RTD MOWs to use other methods to perform CWR maintenance tasks. It is important to provide adequate direction and understanding to maintenance personnel as to what is required to leave the track fit afterwork is performed.

RTD MOWs should include thermal rail adjustment methods and procedures not only for running rail, but also on restraining rails and the guardrails used to guide derailed cars on bridges or placed to protect wayside structures. These rails also expand and contract and can cause problems or affect train operations. In some cases, the equipment normally used for thermal rail adjustment, such



as rail heaters and rail pullers, will not work. Methods should be developed and used by the RTD MOWs that require them. RTD MOWs should include these methods and practices in their procedures.

B.10.1 Rail adjustment distance

RTD MOWs should determine how much distance should be thermally adjusted along the rail when it is disturbed. Some RTD MOWs use as little as 200 ft. in each direction; others use as much as 500 ft.. Whatever the distance a system uses, it should be clearly defined. This distance policy should include some direction concerning what it determines as fixed objects. Items such as frogs, crossing diamonds, etc., can be used as an end-to-rail adjustment. For example, if the rail is cut 100 ft. from a frog (along the same rail), it may not be necessary to adjust the rail 200 ft. back on that end, just up to the frog. Again, the RTD MOW's practice should be clearly defined. To reduce confusion, 200 ft. is used in the following recommended procedures. This distance may not be appropriate for a particular RTD MOW. Each transit system should assess the required distance and make its own determination.

B.10.2 New construction of CWR track

- a) Prior to performing any thermal rail adjustment, all surface and alignment should be completed.
- b) Remove rail clips and/or rail anchors. On cut spike track, the rail should slide through the plates. The rail should be vibrated to bring it to a relaxed condition.
- c) Create adjustment stations by creating match marks on the rail, at least every 200 ft., on the rail base and tie or tie plates. Ensure that the match marks on the tie or tie plates cannot be disturbed by possible movement of the tie and/or plate.
- d) Measure the rail temperature.
- e) Determine the difference between the current rail temperature and the PRLT.
- f) Using the temperature difference, determine the amount of rail movement required at each adjustment station. The movement should be accumulative. For example, if ½ in. of movement is required at the first station, then 1 in. will be required at the second, 1½ in. at the next and so on. Do not use the same rail movement calculated for 200 ft. repeatedly; rather use the amount individually calculated for 200 ft., 400 ft., 600 ft., etc. This will eliminate any accumulative errors created by rounding. This is particularly important when long strings of CWR are adjusted.
- g) Adjust the temperature of the rail until the desired movement of the rail is obtained at the first adjustment station, and anchor the rail up to that station.



- h) Continue until the desired rail movement has occurred at all the adjustment stations.
- i) At the end point of previous track construction or at tie-in locations on existing track, the existing track should be readjusted at least 200 ft. back. Ends of track tend to pull back in the same way, as it is easier to pull a chain than to push it. This lowers the neutral rail temperature.

Note

The temperature of the rail should be constantly monitored throughout the adjustment process. If the rail temperature changes, then the amount of rail movement at subsequent stations should be recalculated.

During rail adjustment, the rail should be vibrated to aid rail movement through the rail seats. Do not hit the rail with hammers, as this will damage the rail. If a rail vibrator is not available, then use special brass or rubber-faced hammers for knocking the rail. If special hammers are not available, then tap on the tie plates or tie shoulders with a sledgehammer.

If the CWR is to be field welded, gaps should be left for the field weld. The OEM of the field weld kit should determine the amount of gap; typically the gap required is 1 in. Some choose to use a short piece of rail to maintain this gap. If the rail is to be field welded at a later date, this protects the rail ends from batter and other damage from construction equipment moving over the track. Others choose to cut the required gap when the actual field weld is made. In no case should the rail be allowed to move back to create the gap needed for a field weld. If this is done, then the NRT will be reduced.

If the track has to be repaired after the rail adjustment is completed, then the CWR should be readjusted. For example if CWR track has to be resurfaced and/or realigned, beyond spot work, then both rails of the CWR track through the disturbed track should be readjusted. Another example would be a weld that is found to be defective or an insulated rail joint that needs to be added. In this case the disturbed rail should be readjusted in the same manner as a pull-apart or a broken rail.

Both rails should be simultaneously adjusted. When one rail at a time is to be adjusted, then the adjustment of one rail should not proceed too far ahead of the other. This will prevent any undue stress on the ties and fasteners and prevent slewing of the ties.

B.10.3 Installing CWR in existing track

- a) Prior to cutting the existing rail, place reference marks ahead of the beginning and end locations to ensure that normal movement occurs on the existing track. If necessary, readjust the rail anchors on each side of the beginning and ending location to keep the existing rail from being disturbed.
- b) If no rail movement occurs after the cut is made, then no further adjustment is required to the existing rail. If rail movement occurs, then the existing rail should be adjusted at least 200 ft. back.
- c) After the new rail is placed and lagged, measure the rail temperature.
- d) Determine the difference between the current rail temperature and the PRLT.
- e) Using the temperature difference, determine the amount of rail movement required at each adjustment station. The movement should be accumulative. For example, if ½ in. of movement is required at the first station, then 1 in. will be required at the second, 1½ in. at the next and so on. Do not use the same rail movement calculated for 200 ft. repeatedly; rather use the amount individually calculated for 200 ft., 400 ft., 600 ft., etc. This will eliminate any accumulative errors created by the



rounding. This is particularly important when long strings of CWR are adjusted.

- f) Adjust the temperature of the rail until the desired movement of the rail is obtained at the first adjustment station and anchor the rail up to that station.
- g) Continue until the desired rail movement has occurred at all the adjustment stations.

Note

The temperature of the rail should be constantly monitored throughout the adjustment process. If the rail temperature changes, then the amount of rail movement at subsequent stations should be recalculated.

During rail adjustment, the rail should be vibrated to aid rail movement through the rail seats. Do not hit the rail with hammers, as this will damage the rail. If a rail vibrator is not available, then use special brass or rubber-faced hammers for knocking the rail. If special hammers are not available, then tap on the tie plates or tie shoulders with a sledgehammer.

If the CWR is to be field welded, gaps should be left for the field weld. The OEM of the field weld kit should determine the gap; typically the required gap is 1 in. Some choose to use a short piece of rail to maintain this gap. If the rail is to be field welded at a later date, this protects the rail ends from batter and other damage from construction equipment moving over the track. Others choose to cut the required gap when the actual field weld is made. In no case should the rail be allowed to move back to create the gap needed for a field weld. If this is done, then the NRT will be reduced.

Where both rails are replaced at the same time, both should be simultaneously adjusted. When one rail is to be adjusted at a time, the adjustment of one rail should not proceed too far ahead of the other. This will prevent any undue stress on the ties and fasteners and prevent slewing of the ties.

B.10.4 Repair of broken rails and pull-aparts in CWR track

- a) If the rail temperature is hot, or is expected to rise during the repair process, then the rail ends should be bypassed to ensure that the rail ends will not jam.
- b) Remove the rail anchors and/or fasteners for 200 ft. on each side of the gap in the rail, along the disturbed rail. Remove the anchors or fasteners beginning at the gap in the rail, working away from the gap. Otherwise, the last few ties or fasteners near the gap will become overstressed when the remaining anchors or fasteners have been removed.
- c) Vibrate the rail to ensure that it is at its natural length.
- d) Measure the rail temperature.
- e) Determine the difference between the current rail temperature and the PRLT.
- f) Using the temperature difference, determine the amount of rail movement required for 400 ft.. If the gap is more than the required rail movement, then additional rail is required, and a rail will need to be cut in.
- g) If the rail temperature is less than the PRLT, then cut the rail ends to provide the required gap. If the rail temperature is above the PRLT, then cut the rail ends to provide the required overlap. If the rail temperature is equal to the PRLT, then no gap is required. If the rail is to be field welded, then provide the additional gap required for the field weld. Where the rail temperature is more than the PRLT,



then the gap required for the field weld should be subtracted from the overlap.

- h) Thermally adjust the rail until the rail ends match.
- i) Join the rail, using rail joint(s) or field welding as required.

Note

During rail adjustment, the rail should be vibrated to aid rail movement through the rail seats. Do not hit the rail with hammers, as this will damage the rail. If a rail vibrator is not available, then use special brass or rubber-faced hammers for knocking the rail. If special hammers are not available, then tap on the tie plates or tie shoulders with a sledgehammer.

RTD MOWs should determine the minimum length of rail that can be used for making repairs. This minimum rail length should be reiterated in the RTD MOW's rail adjustment procedure, where instructions are given for installing rail.

Some RTD MOWs drill only the holes furthest from the rail ends on rail joints that are to be welded at a later date. The policies and procedure for securing rail joints should be reiterated in the RTD MOW's rail adjustment procedure, where instructions are given for creating rail joints in CWR track.


B.10.5 Repair of sun kinks or suspected improperly adjusted rail in CWR track

- a) Carefully cut the rail(s). If the rail is to be cut with a rail saw, then the stress can be relieved by removing the rail from its rail seats and aligning it away from the rail seats or snaking the rail to allow its length to increase. Great care should be taken when cutting the rail when it is under compression; the rail should be secured so it cannot jump out of place. Personnel should position themselves out of harm's way.

- b) Remove the rail anchors and/or fasteners for at least 200 ft. on each side of the gap in the rail, along the disturbed rail. Remove the anchors or fasteners beginning at the cut previously made in the rail, working away from the gap. Otherwise, the last few ties or fasteners near the gap will become overstressed when the remaining anchors or fasteners have been removed.
- c) Vibrate the rail to ensure it is at its natural length.
- d) Measure the rail temperature.
- e) Determine the difference between the current rail temperature and the PRLT.
- f) Using the temperature difference, determine the amount of rail movement required for the distance that the rail anchors or fasteners were removed. If the gap is more than the required rail movement, then additional rail is required, and a rail will need to be cut in.
- g) Thermally adjust the rail until the rail ends match.
- h) Join the rail, using rail joint(s) or field welding as required.
- i) The track should be realigned and resurfaced as required. Prior to releasing the track to unrestricted train movement, the ballast section should be restored as required.

Note

Typically, both rails should be adjusted at a location of a sun kink. Unless there is specific information, such as a known maintenance procedure that had previously taken place without proper rail adjustment, then both rails should be adjusted. In any case, the safe course



should be taken; if there is any doubt, then both rails should be adjusted.

The distance that the rail needs to be adjusted should be determined on a case-by-case basis. The cause of the sun kink should be determined. In newly constructed track, adjacent rail segments should be considered suspect, and if not adjusted, they should be carefully watched. Where surface and alignment has recently been performed on a curve, then the track may have been aligned inward, reducing the adjustment of the rail. If this is the case, then both rails on the entire curve should be thermally readjusted or the curve realigned. If a defective rail was repaired or a weld made, then that should be looked to as the cause. Where rail has been relayed with CWR, then the adjustment made when the renewal was made should be suspect. Whatever the problem, careful thought should be made as to the cause and appropriate action taken to prevent another sun kink nearby. In no case should the adjustment distance be less than that required by the RTD MOW.

If the rail is to be cut with a torch, first cut away approximately 3 in. of the railhead, and then cut away approximately 3 in. of the rail base, then through the web. If this does not relieve the compressive forces in the rail, then repeat the process. Personnel should position themselves out of harm's way while the cut is being made. Many RTD MOWs have policies concerning torch-cut rails. Some RTD MOWs forbid torch-cut rail ends; in these cases, the torch-cut rail ends will need to be cut off. How far back the cuts need to be made generally varies from 3 to 6 in. to eliminate shatter cracks caused by the torch cutting and the potential of rail breaks. Some RTD MOWs allow torch-cut rail ends to be field welded if the weld is made within an hour of when the cut was made. Whatever the policies of the RTD MOW, they should be reiterated in its rail adjustment procedure, where instructions are given for cutting rail in CWR track.

During rail adjustment, the rail should be vibrated to aid rail movement through the rail seats. Do not hit the rail with hammers, as this will damage the rail. If a rail vibrator is not available, then use special brass or rubber-faced hammers for knocking the rail. If special hammers are not available, then tap on the tie plates or tie shoulders with a sledghammer.

Drill only the holes furthest from the rail ends on rail joints that are to be welded later. The policies and procedure for securing rail joints should be reiterated in the RTD MOW's rail adjustment procedure, where instructions are given for creating rail joints in CWR track.

B.10.6 Cutting in a rail or rail joint in CWR track

- a) Cut the rail at the desired location, taking the necessary precautions (see Notes below).
- b) Remove the rail anchors and/or fasteners for at least 200 ft. on each side of the cut in the rail, along the disturbed rail. Remove the anchors or fasteners beginning at the cut, working away from the cut. Otherwise, the last few ties or fasteners near the gap will become overstressed when the remaining anchors or fasteners have been removed.
- c) Vibrate the rail to ensure that it is at its natural length.
- d) Measure the rail temperature.
- e) Determine the difference between the current rail temperature and the PRLT.
- f) Using the temperature difference, determine the amount of rail movement required for the distance that the rail anchors or fasteners were removed. If the gap is more than the required rail movement, then additional rail is required, and a rail will need to be cut in.
- g) Thermally adjust the rail until the rail ends match.
- h) Join the rail, using rail joint(s) or field welding as required.

Note

If the current rail temperature is higher than the neutral rail temperature, then expect the rail to bind when cut. If the rail is to be cut with a rail saw, then the stress can be relieved by removing the rail from its rail seats and aligning it away from the rail seats or snaking the rail to allow its length to increase. Great care should be taken when cutting the rail when it is under



compression; the rail should be secured so it cannot jump out of place. Personnel should position themselves out of harm's way.

If the rail is cut with a torch and it is under compression, first cut away approximately 3 in. of the railhead, and then cut away approximately 3 in. of the rail base, then through the web. If this does not relieve the compressive forces in the rail, then repeat the process. Personnel should position themselves out of harm's way while the cut is being made. Many RTD MOWs have policies concerning torch-cut rails. Some RTD MOWs forbid torch-cut rail ends. In these cases, the torch-cut rail ends will need to be cut off. How far back the cuts need to be made generally varies from 3 to 6 in. to eliminate shatter cracks caused by the torch cutting and the potential of rail breaks. Some RTD MOWs allow torch-cut rail ends to be field welded if the weld is made within an hour of when the cut was made. Whatever the policies of the RTD MOW, they should be reiterated in its rail adjustment procedure, where instructions are given for cutting rail in CWR track.

If the rail temperature is significantly lower than the neutral rail temperature, then precautions should be taken to prevent the rail from tearing when the cut is partially made. The rail anchors facing the location where the cut is to be made should be tightly adjusted against the ties. Where direct fixation fasteners or resilient fasteners are used, a sufficient number of fasteners should be loosened to prevent damage to the ties, fasteners or anchor bolts. In the case of ties, expect some of the ties to be skewed when the rail is cut. In extreme cases, the ties may lift out of the tamp beds and need to be dug back down.

During rail adjustment, the rail should be vibrated to aid rail movement through the rail seats. Do not hit the rail with hammers, as this will damage the rail. If a rail vibrator is not available, then use special brass or rubber-faced hammers for knocking the rail. If special hammers are not available, then tap on the tie plates or tie shoulders with a sledgehammer.

If the CWR is to be field welded, then gaps should be left for the field weld. The OEM of the field weld kits should determine the gap, typically 1 in. Some choose to use a short piece of rail to maintain this gap. If the rail is to be field welded at a later date, this protects the rail ends from batter and other damage from construction equipment moving over the track. Others choose to cut the required gap when the actual field weld is made. In no case should the rail be allowed to move back to create the gap needed for a field weld. If this is done, then the NRT will be reduced.

RTD MOWs should determine the minimum length of rail that can be used for making repairs. This minimum rail length should be reiterated in the RTD MOW's rail adjustment procedure, where instructions are given for installing rail.

Some RTD MOWs drill only the holes furthest from the rail ends on rail joints that are to be welded at a later date. The policies and procedure for securing rail joints should be reiterated in the RTD MOW's rail adjustment procedure, where instructions are given for creating rail joints in CWR track.

B.11 Communication and record keeping

Good communication among the different people working on, disturbing and maintaining CWR track is a key element in preventing problems. This communication can be an extensive effort, particularly when the number of people, shifts and divisions increases. For example, if a repair crew from another section is called in on a holiday to repair a pull-apart, it is critical for the personnel who normally maintain and inspect the track to know and understand what was done to repair the CWR track. Questions that need to be answered include the following: Where was the repair made? Was the rail readjusted? If so, to what temperature? Which rail?

One of the key elements to maintaining a given stretch of track is knowing exactly where something has been done and what has been done to it. Even in smaller organizations, communicating and record keeping are equally important. In these situations, the entire maintenance and work history can easily be kept in the collective memory of the few maintenance personnel; however, others that follow along later have no access to this information. Construction and contract



management groups also affect CWR track. It is not uncommon for the contracts that they manage to be written for new construction, not for maintenance activities. Those managing contractors may be unaware or unable to compel contractors to provide the information required by maintenance personnel due to contractual limitations. These challenges must be overcome.

The record kept when maintaining CWR track should, at a minimum, provide the rail temperature, location, which rail and date of CWR installations. This same information should be recorded when CWR track is disturbed by maintenance or construction activities that can disturb the

rail temperature. It is especially important to record locations where the rail installation or track work does not conform to the RTD MOW's procedures, in particular when rail is added by these tasks. These records should be made available in a timely manner to those responsible for maintaining and inspecting the track. Special effort should be made by RTD MOWs to ensure that crews return as soon as possible to properly readjust the rail. If these records are not maintained, the usual effect is later impacts to the operations of trains.

An example of a CWR disturbance report is shown in **Figure B2**.

FIGURE B2
Example CWR Disturbance Report

Date CWR was disturbed: _____	
Division or line: _____	Track: _____ Milepost or engineering station: _____
Rail: <input type="checkbox"/> North <input type="checkbox"/> South <input type="checkbox"/> East <input type="checkbox"/> West	
Weather: _____	
Type of work performed: <input type="checkbox"/> Rail replacement <input type="checkbox"/> Pull-apart <input type="checkbox"/> Broken rail <input type="checkbox"/> Sun kink	
<input type="checkbox"/> Other (explain): _____	
Amount of rail added or removed: _____	Distance rail was adjusted or moved: _____
Was rail properly adjusted? <input type="checkbox"/> Yes <input type="checkbox"/> No	
Was rail cut? <input type="checkbox"/> Yes <input type="checkbox"/> No	Temperature rail was adjusted to: _____
Reason rail was not properly adjusted: _____	

Person completing report: _____	Date report completed: _____



B.12 Benefits of CWR

CWR eliminates the need for rail end welding, battered rail joints, cracked angle bars, broken joint bolts, retorquing rail joints, and surfacing and gaging at rail joints. It decreases resistance for traction power ground return and improves signal circuit reliability. Tie life is also increased, along with the life of the rail. In addition to all of this, surfacing and aligning cycles are greatly lengthened. Another benefit is a reduction in noise from passing trains.

B.13 References

There is a large amount of published material available concerning the maintenance of CWR. Much research has been performed, and more is underway. Different predictive models and various versions of computer software are available for predicting the effects of temperature changes on CWR track. An excellent resource is the AREMA “Manual for Railway Engineering” In particular, reference Volume 1, Chapter 5. Another good source is FTA’s “Pocket Guide: Compilation of Rail Transit Industry Best Practices for Track Inspection and Maintenance.”



B.14 Thermal rail adjustment table

Table B3 details the changes in unrestrained rail length for given rail lengths and temperature changes, using the following formula:

$$\Delta RL = RL \times \Delta T \times 0.000078, \text{ where}$$

ΔRL = change in rail length (in inches) RL = rail length (in feet)

ΔT = change in rail temperature (in Fahrenheit degrees)

TABLE B3
Change in Rail Length

		RL Rail Length							
		100 ft.	200 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.	800 ft.
ΔT = Change in Rail Temperature	5 °F	1/16 in.	1/16 in.	1/8 in.	1/8 in.	3/16 in.	1/4 in.	1/4 in.	5/16 in.
	10 °F	1/16 in.	1/8 in.	1/4 in.	5/16 in.	3/8 in.	7/16 in.	9/16 in.	5/8 in.
	15 °F	1/8 in.	1/4 in.	3/8 in.	7/16 in.	9/16 in.	11/16 in.	13/16 in.	15/16 in.
	20 °F	1/8 in.	5/16 in.	7/16 in.	5/8 in.	3/4 in.	15/16 in.	1 1/16 in.	1 1/4 in.
	25 °F	3/16 in.	3/8 in.	9/16 in.	3/4 in.	1 in.	1 3/16 in.	1 3/8 in.	1 9/16 in.
	30 °F	1/4 in.	7/16 in.	11/16 in.	15/16 in.	1 3/16 in.	1 3/8 in.	1 5/8 in.	1 7/8 in.
	35 °F	1/4 in.	9/16 in.	13/16 in.	1 1/16 in.	1 3/8 in.	1 5/8 in.	1 15/16 in.	2 3/16 in.
	40 °F	5/16 in.	5/8 in.	15/16 in.	1 1/4 in.	1 9/16 in.	1 7/8 in.	2 3/16 in.	2 1/2 in.
	45 °F	3/8 in.	11/16 in.	1 1/16 in.	1 3/8 in.	1 3/4 in.	2 1/8 in.	2 7/16 in.	2 13/16 in.
	50 °F	3/8 in.	3/4 in.	1 3/16 in.	1 9/16 in.	1 15/16 in.	2 5/16 in.	2 3/4 in.	3 1/8 in.
	55 °F	7/16 in.	7/8 in.	1 5/16 in.	1 11/16 in.	2 1/8 in.	2 9/16 in.	3 in.	3 7/16 in.
	60 °F	7/16 in.	15/16 in.	1 3/8 in.	1 7/8 in.	2 5/16 in.	2 13/16 in.	3 1/4 in.	3 3/4 in.
	65 °F	1/2 in.	1 in.	1 1/2 in.	2 in.	2 9/16 in.	3 1/16 in.	3 9/16 in.	4 1/16 in.
	70 °F	9/16 in.	1 1/16 in.	1 5/8 in.	2 3/16 in.	2 3/4 in.	3 1/4 in.	3 13/16 in.	4 3/8 in.
	75 °F	9/16 in.	1 3/16 in.	1 3/4 in.	2 5/16 in.	2 15/16 in.	3 1/2 in.	4 1/8 in.	4 11/16 in.
80 °F	5/8 in.	1 1/4 in.	1 7/8 in.	2 1/2 in.	3 1/8 in.	3 3/4 in.	4 3/8 in.	5 in.	

TABLE B3
Change in Rail Length (continued)

		Rail Length							
		900 ft.	1000 ft.	1100 ft.	1200 ft.	1300 ft.	1400 ft.	1440 ft.	1500 ft.
ΔT = Change in Rail Temperature	5 °F	3/8 in.	3/8 in.	7/16 in.	7/16 in.	1/2 in.	9/16 in.	9/16 in.	9/16 in.
	10 °F	1 1/16 in.	3/4 in.	7/8 in.	15/16 in.	1 in.	1 1/16 in.	1 1/8 in.	1 3/16 in.
	15 °F	1 1/16 in.	1 3/16 in.	1 5/16 in.	1 3/8 in.	1 1/2 in.	1 5/8 in.	1 11/16 in.	1 3/4 in.
	20 °F	1 3/8 in.	1 9/16 in.	1 11/16 in.	1 7/8 in.	2 in.	2 3/16 in.	2 1/4 in.	2 5/16 in.
	25 °F	1 3/4 in.	1 15/16 in.	2 1/8 in.	2 5/16 in.	2 9/16 in.	2 3/4 in.	2 13/16 in.	2 15/16 in.
	30 °F	2 1/8 in.	2 5/16 in.	2 9/16 in.	2 13/16 in.	3 1/16 in.	3 1/4 in.	3 3/8 in.	3 1/2 in.
	35 °F	2 7/16 in.	2 3/4 in.	3 in.	3 1/4 in.	3 9/16 in.	3 13/16 in.	3 15/16 in.	4 1/8 in.
	40 °F	2 13/16 in.	3 1/8 in.	3 7/16 in.	3 3/4 in.	4 1/16 in.	4 3/8 in.	4 1/2 in.	4 11/16 in.
	45 °F	3 3/16 in.	3 1/2 in.	3 7/8 in.	4 3/16 in.	4 9/16 in.	4 15/16 in.	5 1/16 in.	5 1/4 in.
	50 °F	3 1/2 in.	3 7/8 in.	4 5/16 in.	4 11/16 in.	5 1/16 in.	5 7/16 in.	5 5/8 in.	5 7/8 in.
	55 °F	3 7/8 in.	4 5/16 in.	4 3/4 in.	5 1/8 in.	5 9/16 in.	6 in.	6 3/16 in.	6 7/16 in.
	60 °F	4 3/16 in.	4 11/16 in.	5 1/8 in.	5 5/8 in.	6 1/16 in.	6 9/16 in.	6 3/4 in.	7 in.
	65 °F	4 9/16 in.	5 1/16 in.	5 9/16 in.	6 1/16 in.	6 9/16 in.	7 1/8 in.	7 5/16 in.	7 5/8 in.
	70 °F	4 15/16 in.	5 7/16 in.	6 in.	6 9/16 in.	7 1/8 in.	7 5/8 in.	7 7/8 in.	8 3/16 in.
	75 °F	5 1/4 in.	5 7/8 in.	6 7/16 in.	7 in.	7 5/8 in.	8 3/16 in.	8 7/16 in.	8 3/4 in.
	80 °F	5 5/8 in.	6 1/4 in.	6 7/8 in.	7 1/2 in.	8 1/8 in.	8 3/4 in.	9 in.	9 3/8 in.
	85 °F	5 15/16 in.	6 5/8 in.	7 5/16 in.	7 15/16 in.	8 5/8 in.	9 5/16 in.	9 9/16 in.	9 15/16 in.
	90 °F	6 5/16 in.	7 in.	7 3/4 in.	8 7/16 in.	9 1/8 in.	9 13/16 in.	10 1/8 in.	10 1/2 in.
	95 °F	6 11/16 in.	7 7/16 in.	8 1/8 in.	8 7/8 in.	9 5/8 in.	10 3/8 in.	10 11/16 in.	11 1/8 in.
	100 °F	7 in.	7 13/16 in.	8 9/16 in.	9 3/8 in.	10 1/8 in.	10 15/16 in.	11 1/4 in.	11 11/16 in.
85 °F	1 1/16 in.	1 5/16 in.	2 in.	2 5/8 in.	3 5/16 in.	4 in.	4 5/8 in.	5 5/16 in.	
90 °F	1 1/16 in.	1 3/8 in.	2 1/8 in.	2 13/16 in.	3 1/2 in.	4 3/16 in.	4 15/16 in.	5 5/8 in.	
95 °F	3/4 in.	1 1/2 in.	2 1/4 in.	2 15/16 in.	3 11/16 in.	4 7/16 in.	5 3/16 in.	5 15/16 in.	
100 °F	3/4 in.	1 9/16 in.	2 5/16 in.	3 1/8 in.	3 7/8 in.	4 11/16 in.	5 7/16 in.	6 1/4 in.	

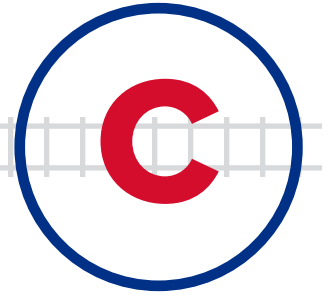
B.15 Desired rail laying temperature range table

Table B4 provides desired rail-laying temperature ranges for selected high and low rail temperatures. The PRLT used by a RTD MOW should be within the ranges shown in **Table B4**, given the high and low rail temperatures that the system experiences. For more information, see Section B.3.



TABLE B4
Desired Rail Laying Temperature Ranges

	Highest Rail Temperature (Ht)							
	80° F	90° F	100° F	110° F	120° F	130° F	140° F	150° F
- 40° F	50.0 °F to 65.0 ±5 °F	56.7 °F to 71.7 ±5 °F	63.3 °F to 78.3 ±5 °F	70.0 °F to 85.0 ±5 °F	76.7 °F to 91.7 ±5 °F	83.3 °F to 98.3 ±5 °F	90.0 °F to 105.0 ±5 °F	96.7 °F to 111.7 ±5 °F
- 35° F	51.7 °F to 66.7 ±5 °F	58.3 °F to 73.3 ±5 °F	65.0 °F to 80.0 ±5 °F	71.7 °F to 86.7 ±5 °F	78.3 °F to 93.3 ±5 °F	85.0 °F to 100.0 ±5 °F	91.7 °F to 106.7 ±5 °F	98.3 °F to 113.3 ±5 °F
- 30° F	53.3 °F to 68.3 ±5 °F	60.0 °F to 75.0 ±5 °F	66.7 °F to 81.7 ±5 °F	73.3 °F to 88.3 ±5 °F	80.0 °F to 95.0 ±5 °F	86.7 °F to 101.7 ±5 °F	93.3 °F to 108.3 ±5 °F	100.0 °F to 115.0 ±5 °F
- 25° F	55.0 °F to 70.0 ±5 °F	61.7 °F to 76.7 ±5 °F	68.3 °F to 83.3 ±5 °F	75.0 °F to 90.0 ±5 °F	81.7 °F to 96.7 ±5 °F	88.3 °F to 103.3 ±5 °F	95.0 °F to 110.0 ±5 °F	101.7 °F to 116.7 ±5 °F
- 20° F	56.7 °F to 71.7 ±5 °F	63.3 °F to 78.3 ±5 °F	70.0 °F to 85.0 ±5 °F	76.7 °F to 91.7 ±5 °F	83.3 °F to 98.3 ±5 °F	90.0 °F to 105.0 ±5 °F	96.7 °F to 111.7 ±5 °F	103.3 °F to 118.3 ±5 °F
- 15° F	58.3 °F to 73.3 ±5 °F	65.0 °F to 80.0 ±5 °F	71.7 °F to 86.7 ±5 °F	78.3 °F to 93.3 ±5 °F	85.0 °F to 100.0 ±5 °F	91.7 °F to 106.7 ±5 °F	98.3 °F to 113.3 ±5 °F	105.0 °F to 120.0 ±5 °F
- 10° F	60.0 °F to 75.0 ±5 °F	66.7 °F to 81.7 ±5 °F	73.3 °F to 88.3 ±5 °F	80.0 °F to 95.0 ±5 °F	86.7 °F to 101.7 ±5 °F	93.3 °F to 108.3 ±5 °F	100.0 °F to 115.0 ±5 °F	106.7 °F to 121.7 ±5 °F
- 5° F	61.7 °F to 76.7 ±5 °F	68.3 °F to 83.3 ±5 °F	75.0 °F to 90.0 ±5 °F	81.7 °F to 96.7 ±5 °F	88.3 °F to 103.3 ±5 °F	95.0 °F to 110.0 ±5 °F	101.7 °F to 116.7 ±5 °F	108.3 °F to 123.3 ±5 °F
0° F	63.3 °F to 78.3 ±5 °F	70.0 °F to 85.0 ±5 °F	76.7 °F to 91.7 ±5 °F	83.3 °F to 98.3 ±5 °F	90.0 °F to 105.0 ±5 °F	96.7 °F to 111.7 ±5 °F	103.3 °F to 118.3 ±5 °F	110.0 °F to 125.0 ±5 °F
5° F	65.0 °F to 80.0 ±5 °F	71.7 °F to 86.7 ±5 °F	78.3 °F to 93.3 ±5 °F	85.0 °F to 100.0 ±5 °F	91.7 °F to 106.7 ±5 °F	98.3 °F to 113.3 ±5 °F	105.0 °F to 120.0 ±5 °F	111.7 °F to 126.7 ±5 °F
10° F	66.7 °F to 81.7 ±5 °F	73.3 °F to 88.3 ±5 °F	80.0 °F to 95.0 ±5 °F	86.7 °F to 101.7 ±5 °F	93.3 °F to 108.3 ±5 °F	100.0 °F to 115.0 ±5 °F	106.7 °F to 121.7 ±5 °F	113.3 °F to 128.3 ±5 °F
15° F	68.3 °F to 83.3 ±5 °F	75.0 °F to 90.0 ±5 °F	81.7 °F to 96.7 ±5 °F	88.3 °F to 103.3 ±5 °F	95.0 °F to 110.0 ±5 °F	101.7 °F to 116.7 ±5 °F	108.3 °F to 123.3 ±5 °F	115.0 °F to 130.0 ±5 °F
20° F	70.0 °F to 85.0 ±5 °F	76.7 °F to 91.7 ±5 °F	83.3 °F to 98.3 ±5 °F	90.0 °F to 105.0 ±5 °F	96.7 °F to 111.7 ±5 °F	103.3 °F to 118.3 ±5 °F	110.0 °F to 125.0 ±5 °F	116.7 °F to 131.7 ±5 °F
25° F	71.7 °F to 86.7 ±5 °F	78.3 °F to 93.3 ±5 °F	85.0 °F to 100.0 ±5 °F	91.7 °F to 106.7 ±5 °F	98.3 °F to 113.3 ±5 °F	105.0 °F to 120.0 ±5 °F	111.7 °F to 126.7 ±5 °F	118.3 °F to 133.3 ±5 °F
30° F	73.3 °F to 88.3 ±5 °F	80.0 °F to 95.0 ±5 °F	86.7 °F to 101.7 ±5 °F	93.3 °F to 108.3 ±5 °F	100.0 °F to 115.0 ±5 °F	106.7 °F to 121.7 ±5 °F	113.3 °F to 128.3 ±5 °F	120.0 °F to 135.0 ±5 °F
35° F	75.0 °F to 90.0 ±5 °F	81.7 °F to 96.7 ±5 °F	88.3 °F to 103.3 ±5 °F	95.0 °F to 110.0 ±5 °F	101.7 °F to 116.7 ±5 °F	108.3 °F to 123.3 ±5 °F	115.0 °F to 130.0 ±5 °F	121.7 °F to 136.7 ±5 °F
40° F	76.7 °F to 91.7 ±5 °F	83.3 °F to 98.3 ±5 °F	90.0 °F to 105.0 ±5 °F	96.7 °F to 111.7 ±5 °F	103.3 °F to 118.3 ±5 °F	110.0 °F to 125.0 ±5 °F	116.7 °F to 131.7 ±5 °F	123.3 °F to 138.3 ±5 °F

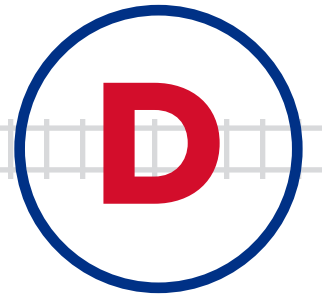


Appendix C: Rail wear practices

Rail wear shall be monitored for prioritization in terms of when to replace it (including a cautionary stage for close monitoring). Worn rail, per se (in the absence of defects related to shelling, contact stresses, wheel flanges hitting joint bars or other objects, etc.) is not inherently a safety issue. Table C1, applicable to 115RE rail, is provided is best for maintenance practices.

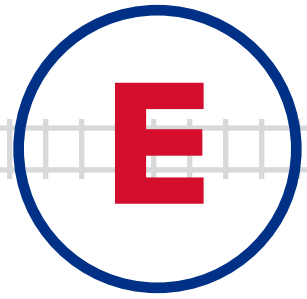
TABLE C1
Rail Wear Limits

Rail Wear	Monitor	Change Rail
Running rail vertical wear	> $\frac{3}{8}$ in.	> $\frac{1}{2}$ in.
Running rail side wear	> $\frac{5}{16}$ in.	> $\frac{1}{2}$ in.
Guardrail side wear	> $\frac{1}{4}$ in.	> $\frac{7}{16}$ in.



Appendix D: Special track work practices

- a) Special attention is necessary when renewing stock rails to provide a full rail “seat” and to avoid any canting of rails before they are placed in service.
- b) When renewal of worn switch points or stock rails is necessary, as a rule both the point and stock rail should be changed out simultaneously. Under no circumstances shall a new switch point be placed against a worn stock rail. When renewal of the unguarded point is required, the housetop, the guardrail preceding the housetop and the straight stock rail shall also be replaced. Special attention to stock rail slide plates is necessary to prevent any lateral or vertical movement. Worn slide plates shall be renewed when changing out stock rails.
- c) When renewing frogs, care shall be exercised to provide frog point protection by checking guardrail gage and adjusting it as necessary.



Appendix E (informational): Typical track and switch inspection forms

Following are examples of typical track and switch inspection forms used by RTD MOWs.

Track Inspector Reporting Form

Name (please print) _____

Date

M	D	Y

Page ___ of ___

Employee Pass No.				

Section		

Inspection Type		
14 Day	Sp	Trk

Title Code		

Total Inspection Lines	

Total Complaint(s)	

Total Defect Lines	

Inspection				Complaints												
Sequence Number		Time		Complaint #	Sequence Number		Stationing Markers				Switch Number	Component	Defect	Status	Rail E/W/B	Complaint Reference Number
From	To	HH	MM		From	To	Primary Marker	2 nd ary	Primary Marker	2 nd ary						

Compl. #	General Comments and Repairs (Include Line, Track, Location and Column Numbers)	Material Usage	
		Description / Commodity #	Qty

Employee Signature

Supervisory Certification

Codes for Track Inspector Reporting Form

DEFECT CODES	COMPONENT CODES	COMPLAINT STATUS CODES
DEFECTS	FASTENERS	P1 = REPORTED PRIORITY 1 DEFECT
D01 BATTERED	F01 BRIDGE ANCHOR	P2 = REPORTED PRIORITY 2 DEFECT
D02 BLOCKAGE	F02 MACHINE BOLT BRIDGE ANCHOR	P3 = REPORTED PRIORITY 3 DEFECT
D03 BROKEN / SHEARED	F03 RAIL ANCHOR	
D04 BURNT (LUMBER)	F04 TIE SPACER BAR	
D05 CHIPPED / PITTED (<i>Discontinued</i>)	F05 'C' BOLT	
D06 CORRODED	F06 GAUGE ROD (TURNBUCKLE)	
D07 CORRUGATED	F07 'C' CLAMP	
D08 CRACKED / SPLIT	F08 BOLTS	PLATES
D09 CROSS LEVEL IMPROPER	F09 CUT SPIKES	P01 14" 'A' PLATE
D10 DETERIORATING	F10 SCREW LAGS	P02 'B' PLATE
D11 DISHED (WHEEL BURN)	F11 'E' CLIPS	P03 14" 'C' PLATE
D12 FLANGEWAY IMPROPER	F12 MODIFIED 'E' CLIPS	P04 'D' PLATE
D13 FOULED (BALLAST CEMENTED)	F13 HEAVY DUTY 'E' CLIPS	P05 ABRASION PLATE
D14 FROZEN / SEIZED / JAMMED	F14 'J' CLIP (115 lb.)	P06 CONTAINER PLATE
D15 GROOVED	F15 FENCE POST BOLT	P07 RUBBER RAIL SEAT
D16 HARDWARE MISSING	F16 HAND RAIL 'U' BOLT	P08 FILLER PLATE (SHIM)
D17 HIGH SPIKES	F17 LOCK SPIKES	P09 8" PLATE
D18 ICE CONDITION	F18 REINFORCEMENT BOLT	P10 TWIN HOOK PLATE
D19 LATERAL MOVEMENT		P11 PANDROL PLATE
D20 LOOSE / SLACK	INVERT	P12 'B' BRACE (for EPR)
D21 MISSING	I01 BALLAST	P13 SENECA / 'Y' PLATE
D22 MISMATCH	I02 CONCRETE	P14 RESILIENT 'A' PLATE
D23 MUD CONDITION		P15 RESILIENT 'B' PLATE
D24 OUT OF GAUGE	JOINTS (RUNNING RAIL)	P16 RESILIENT 'D' PLATE
D25 OUT OF LINE	J01 INSULATED RAIL JOINT	
D26 OUT OF RISER	J02 BONDED INSULATED JOINT	RAIL
D27 OUT OF SURFACE	J03 END POST, INSULATED JOINT	R01 RUNNING RAIL
D28 POOR SUPPORT	J04 'G' RAIL JOINT BAR	R02 GUARD RAIL
D29 PLATE CUT (TIES, TIE BLOCKS)	J05 'F' RAIL JOINT BAR	R03 CONTACT RAIL
D30 PUMPING	J06 OTHER MECHANICAL JOINTS	R04 EMERGENCY PROTECTION RAIL
D31 ROTTED	J07 CONTINUITY BOND (SIGNAL)	R05 CONTINUOUS WELDED RAIL (CWR)
D32 RUNNING	J08 CONTINUITY BOND (NEGATIVE)	R06 WING RAIL
D33 SETTLED	J09 BOUTET WELD	R07 SCRAP RAIL
D34 SHELLED	J10 FACTORY WELD	R08 SPARE RAIL
D35 SHOULDER WORN (PLATES)		R09 DEFECTIVE RAIL
D36 SKEWED	LUMBER	SWITCH (SPECIAL WORK)
D37 SNOW CONDITION	L01 TIES	S01 SWITCH PLATE
D38 SPIKED KILLED (POOR HOLDING)	L02 TIE BLOCKS	S02 SWITCH CHAIR
D39 TIGHT	L03 SLATTING	S03 HOUSETOP
D40 WATER CONDITION	L04 GUARD TIMBER	S04 STOCK RAIL
D41 BAD WELD	L05 WEDGES	S05 SWITCH POINT
D42 SIDE WORN (RAIL)	L06 EVEVANG BLOCKS	S06 FROG
D43 TOP WORN (RAIL)	L07 CLAMPS, ELEVATION BLOCKS	S07 SWITCH ROD
D44 WORN (as per Standards)	L08 MISCELLANEOUS LUMBER	S08 SWITCH STAND (HAND THROW)
D45 WRONG PART	L09 PROTECTION BOARD (WOOD)	S09 SWITCH BRACES
D46 FIRE	L10 TAPERED TIES	S10 MALLEABLE RAIL STOP
D47 NO HOLES		S11 LIFT RAIL
D48 DEBRIS	MISCELLANEOUS	S12 EXPANSION RAILS
D49 COMBINED CONDITIONS (<i>Reactivated</i>)	M01 DRAINS	S13 CLOSURE RAILS
D50 TRACK / RAIL SHORED	M02 PAPER CATCHER	S14 'P' BOLT
D51 VEGETATION	M03 HANDRAIL	S15 THRU BOLTS / LAGS
D52 PULL APART / GAP	M04 GIRDER	S16 SHOULDER BOLT
D53 INSULATING PAINT REQUIRED	M05 WIRE BASKET	S17 KINK BAR
D54 IMPROPER PATTERN (SPACING)	M06 SEPARATOR BLOCK	S18 HEEL BLOCK
D55 IMPROPER TYPE / SIZE	M07 FENCE POST	S19 DERAILER
D56 IMPROPER STAGGER	M08 LADDER / STAIRWAY	S20 HEEL BOLTS
D57 CHIPPED	M09 EMERGENCY EXIT	S21 GUARDED SWITCH POINT
D58 PITTED	M10 MAN HOLE	S22 UNGUARDED SWITCH POINT
D59 GOUGED	M11 FIBER WALKWAY	S23 FOOT GUARD
D60 SCORCHED	M12 NO CLEARANCE SIGNS	S24 FROG RISER
D61 BASE CORRODED (ONLY)	M13 RAIL LUBRICATOR	S25 FROG POINT
D62 PROPERLY STORED/PLACED	M14 GUARD RAIL NOSING	
D63 IMPROPERLY STORED/PLACED	M15 DRIP PANS	TRACK
D64 HEAD CHECKED	M16 3 RD RAIL INSULATOR	T01 TRACK
	M17 PROTECTION BOARD (FIBERGLASS)	T02 PORTAL AREA
	M18 RUBBING BOARD	T03 ABUTMENT

NOTE: SHADED AREA INDICATES NEW CODES

Joint Switch and Frog Inspection Form

DATE: ___/___/___

GENERAL INFORMATION		SUPERINTENDENT <input type="checkbox"/> MONTHLY <input type="checkbox"/> QUARTERLY <input type="checkbox"/> SPECIAL INSP. _____	
Division:	Line:	Track:	Switch #:
Location:		Classification: Mainline <input type="checkbox"/> Yard <input type="checkbox"/>	Type of Switch: Standard <input type="checkbox"/> Special <input type="checkbox"/>
Configuration: Turnout <input type="checkbox"/> Single X-over <input type="checkbox"/> Double X-over <input type="checkbox"/> Equilateral ("Y") <input type="checkbox"/>		Turnout Size (Frog #):	Point Length:
Switch Hand: LH <input type="checkbox"/> RH <input type="checkbox"/> "Y" <input type="checkbox"/>	Train Traffic: Facing <input type="checkbox"/> Trailing <input type="checkbox"/> Both <input type="checkbox"/>	Rail: 100# <input type="checkbox"/> 115# <input type="checkbox"/>	Track Type:
Point Type: A.R.E.M.A. <input type="checkbox"/> KNUCKLE: 1/2" <input type="checkbox"/> 3/4" <input type="checkbox"/>	KNIFE <input type="checkbox"/> LAP <input type="checkbox"/>	Environment: Dry <input type="checkbox"/> Wet <input type="checkbox"/> Other:	
TRACK SUB-DIVISION:	SECTION:	ZONE:	SIGNAL MAINTAINER'S SECTION:

SWITCH COMPONENTS	GOOD / POOR	DEFECT	REMARKS
Front Rod			
Lock Rods / Lock Dogs			
7/8" Pin			
Cap Screws / Lags			
SWITCH CONDITION & TEST	OK / ADJ.	MEASUREMENT	REMARKS
Straight Stock	Switch Point Facing Up		
	Switch Throw		
	Switch Locking/Adj. Test		
Curved Stock	Switch Point Facing Up		
	Switch Throw		
	Switch Locking/Adj. Test		
Test Operation of Switch (performed at completion of the Joint Switch Inspection): YES <input type="checkbox"/>			
PRINT NAME:	TITLE:	PASS #:	SIGN:

		CONDITION OF SWITCH			MEASUREMENT AND/OR DESCRIPTION & REMARKS (ALSO INDICATE ANY ADJUSTMENTS MADE)
		CODE P3	CODE P2	NO DEFECT P1	
Left Switch Point	Switch Point Gap (at Point Tip)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____ in.
	Switch Point End Condition (first 6')	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Right Switch Point	Switch Point Gap (at Point Tip)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____ in.
	Switch Point End Condition (first 6')	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Left Stock Rail	Switch Braces	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Right Stock Rail	Switch Braces	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Left Housetop	*P Bolt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Housetop Bolts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Housetop Chairs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Chair Fasteners	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Right Housetop	Housetop Wear	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____ in.
	*P Bolt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Housetop Bolts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Chair Fasteners	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Switch Rods		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Switch Ties	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Closure Ties		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Frog Bolts		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Frog Point		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

TRACK GEOMETRY MEASUREMENTS		CODE			TRACK GEOMETRY MEASUREMENTS		CODE			REMARKS
		P3	P2	P1			P3	P2	P1	
Left Stock	Top Wear: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	# 4 (" Track Rod, Straight Side	Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Side Wear: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Crosslevel: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Left Point	Top Wear: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Heel of Switch Point, Turnout Side	Flangeway: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Side Wear: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Right Stock	Top Wear: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Heel of Switch Point, Straight Side	Crosslevel: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Side Wear: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Flangeway: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Right Point	Top Wear: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Point of Frog, Turnout Side	Guard Rail Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Side Wear: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
"S" Plate	Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Point of Frog, Straight Side	Crosslevel: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	E. Flangeway: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Flangeway: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
# 1 Track Rod, Turnout Side	W. Flangeway: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Point of Frog, Turnout Side	Guard Rail Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
# 1 Track Rod, Straight Side	Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Point of Frog, Straight Side	Back-to-Back Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
# 4 (" Track Rod, Turnout Side	Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Point of Frog, Straight Side	Crosslevel: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Crosslevel: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Guard Rail Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
# 4 (" Track Rod, Straight Side	Flangeway: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Point of Frog, Straight Side	Back-to-Back Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Track Gauge: _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

(*): Use the #3 Track Rod for switches with 13 ft. points. CODE: P3 = "Priority 3"; P2 = "Priority 2"; P1 = "Priority 1"

Joint Switch and Frog Inspection Form (continued)

GENERAL:

- **Line:** name of the Line where the switch is located.
- **Track:** actual letter and track number where the switch is located (e.g. E-1, A-2, MM-3, etc.)
- **Type of Switch:** Standard: as per Rail Transit System's standards; Special :anything else.
- **Switch Hand:** standing in front of the switch points looking at the switch: LH if the turnout is to the left, RH if the turnout is to the right, "Y" for equilateral switches (see sketch below).
- **Train Traffic:** Facing: normally the train approaches the switch point from its head panel; Trailing: normally the train approaches the switch from the frog end; Both: for traffic in both directions (middle tracks, Yard leads).
- **Point Type:** A.R.E.M.A.: tapered tip, with undercut stock rail; KNUCKLE: 1/2" offset on stock rail to accommodate the 1/2" point; KNIFE: knife-type switch points resting against a standard rail without undercut; LAP: two offset knife-type points, with standard rails used for stock rails.

SWITCH COMPONENTS and SWITCH CONDITION & TEST: For **Switch Components**, denote the condition of the component as either "Good" or "Poor". If the condition is "Poor" write the defect in the "Defect" column. Perform corrective action and enter it in the "Remarks" column. For **Switch Condition & Test**, if the condition needs to be corrected or adjusted write "ADJ" in the appropriate column (otherwise write "OK"). In the "Remarks" column record the action performed to correct the condition.

- **Switch Front Rod:** Signal personnel must inspect the condition of the front rod, switch feet, foot bolts and all connection points for mechanical security and wear.
- **Signal Lock Rods / Locking Dog:** Locking edges of the opening in lock rods and bars must be square before the obstruction test is performed. Plungers and locking dogs must be full size and corners square at the locking end. Rod and bar must be clear of the locking dog or plunger (when unlocked) and must move freely when operated without binding in its guides. Bolts, nuts and jam nuts must be in place and in good condition.
- **7/8" Pin:** check for excessive lost motion and wear of the 7/8" connecting holes and pin. Ensure that the 7/8" pin is effectively secured with its cotter pin.
- **Switch Machine Cap Screws / Lags:** Signal personnel must inspect the condition of the Cap Screws / Lags for mechanical security and wear.
- **Switch Point Facing Up (both sides):** indicate if the switch point is firmly placed against its stock rail when the point is closed, by entering "OK" in the appropriate column. If the point is open, write the size of the opening in the measurement column and take immediate corrective action to close the switch point.
- **Switch Throw (both sides):** record the actual throw measurement found, i.e. 3 1/2". This measurement shall be taken at the number 1 track rod. If the measurement is between 3 1/4 and 4 inches write "OK" in the appropriate column. If the measurement is less than 3 1/4 inches or greater than 4 inches perform immediate corrective action to correct the throw opening.
- **Switch Locking and Adjustment Test:** Interlocked switches must be tested with the standard 1/4-inch gauge placed between the switch point and the stock rail, 6 inches back from the tip of the point. Switch point detection must also be checked. Non-interlocked switches equipped with electric locks shall be tested and reported in the same manner as interlocked switches. If the switch DOES NOT LOCK when the standard obstruction gauge is inserted, write "OK". If the switch LOCKS with the standard obstruction gauge inserted, corrective action must be taken immediately. Under no circumstances shall a switch that does not pass the locking test be left unattended. The switch must be properly secured for train movements until the condition is corrected. Signal Supervision, Track Supervision and Operations must be notified immediately of any switch that must be secured.
- **Switch Test Operation:** the switch machine must be tested, operated under power a minimum of two times upon completion of the Joint Switch Inspection. The "YES" box must be checked, indicating that the test operation has been completed.

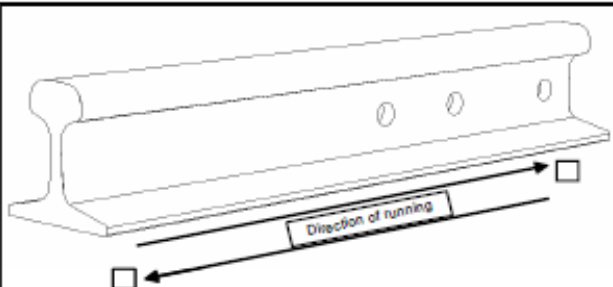
DURING INSPECTION IF CONDITION WARRANT REMOVAL OF SWITCH FROM SERVICE RTO SUPERVISION AND MOW CONTROL MUST BE NOTIFIED. IF SWITCH IS OUT OF SERVICE NOTE THE REASON IN REMARKS AND DISCONTINUE THE INSPECTION.



Report of Rail Failure in Mainline Track

Report of Rail Failure in Mainline Track		
Report date:	Sub-division report #:	Report #:
Found by:	Date found:	Time found: am <input type="checkbox"/> pm <input type="checkbox"/>
Date new rail installed:	Date of temporary repair:	Date of Last UT Run:

1. Location and General Information			
Division:		Line name:	
Location: N/O <input type="checkbox"/> S/O <input type="checkbox"/>		Letter & track #:	
Signal indication? Yes <input type="checkbox"/> No <input type="checkbox"/> N/A <input type="checkbox"/>		Track Sub.-Div.:	
Slow speed needed? Yes <input type="checkbox"/> No <input type="checkbox"/>		Rail affected: Negative <input type="checkbox"/> Signal <input type="checkbox"/>	
Rail Length:		Rail Date:	
Rail Temp.: °F		Switch#:	
2. Track Design			
Track type: Ballasted <input type="checkbox"/> Open Deck <input type="checkbox"/> DF/Slab <input type="checkbox"/> Jointed <input type="checkbox"/> CWR <input type="checkbox"/>		Rail section: 115-lb <input type="checkbox"/> Other <input type="checkbox"/>	
Geometry: Tangent <input type="checkbox"/> Ungrd. Curve <input type="checkbox"/> Guarded Curve <input type="checkbox"/> Special Work <input type="checkbox"/>		Rail type: OH <input type="checkbox"/> CC <input type="checkbox"/> HT <input type="checkbox"/> HH <input type="checkbox"/>	
Tie plates: Single shoulder <input type="checkbox"/> 14" out spikes <input type="checkbox"/> Pandrol (rolled steel) <input type="checkbox"/> Resilient <input type="checkbox"/> Other <input type="checkbox"/>			
Fasteners: Screw lags <input type="checkbox"/> Rubber rail seats <input type="checkbox"/> Cut spikes <input type="checkbox"/> Pandrol <input type="checkbox"/> Other <input type="checkbox"/> Curve Radius (ft.):			
3. Likely Causes of Break			
Nicks & Chips	<input type="checkbox"/> Any evidence that crack started at a nick or chip or gouge on the rail?	Cadweld Bond	<input type="checkbox"/> Did the crack run through or from a Cadweld bond?
Wear on Rail Bottom	<input type="checkbox"/> Was the rail worn on the base from rubbing on the steel plate?	Water	<input type="checkbox"/> Standing water <input type="checkbox"/> Dripping on rail <input type="checkbox"/> Wet (moisture)
Corrosion	<input type="checkbox"/> Was the base of the rail corroded?	Pumping	<input type="checkbox"/> Was the track pumping? <input type="checkbox"/> Were tie blocks loose in the concrete?
Wheel Burns	<input type="checkbox"/> Did the break start from a wheel burn or, <input type="checkbox"/> a repaired wheel burn?	Corrugation	<input type="checkbox"/> Did the rail show a wave along the top – maybe with alternating dark/light patches?
Head Checks	<input type="checkbox"/> Did the break start from cracks or spalls on the rail head?	Joint Condition	<input type="checkbox"/> Open <input type="checkbox"/> Rail Mismatch <input type="checkbox"/> Loose Bolts <input type="checkbox"/> Pumping
Track Geometry	<input type="checkbox"/> Anything unusual about track geometry? Specify:	Rail Weld	<input type="checkbox"/> Field (Thermite) <input type="checkbox"/> Factory (Plant)
Compression (Neg.) Bonds	<input type="checkbox"/> Specify:	Other	<input type="checkbox"/> Specify:

4. Description of Rail Break	
Type of break: Rail broken in two or more pieces <input type="checkbox"/> Piece of head or base broken out <input type="checkbox"/> Crack in rail <input type="checkbox"/>	
Comments: Add anything you think may be significant.	<div style="text-align: center;">  </div> <ul style="list-style-type: none"> ◆ Crack location: Mark the position of the crack and the direction of traffic. ◆ Crack start position: Mark where the crack likely started – this is often where rust is heaviest on the fracture surface. ◆ Plates: Is the break: Over a plate <input type="checkbox"/> Between plates <input type="checkbox"/> At edge of plate <input type="checkbox"/> ◆ Distance from closest joint or weld:



Type of Defect:

Tick the box that best describes the defect.

	<p>Bolt hole cracks BH <input type="checkbox"/></p> <p>These start at bolt holes and mostly grow in the web to form a "star" pattern. If left to grow they cause the rail to break up and the head to break away.</p>		<p>Broken rail BR <input type="checkbox"/> (Head-web-base break)</p> <p>This is used if there is no clear cause of the break. In this picture the rail has failed from wear on the base caused as the rail rubs against the plate. It's a good idea to look closely at the fracture to see if there are any "thumbnail" fatigue cracks.</p>
	<p>Base of web BW <input type="checkbox"/></p> <p>This crack runs along the bottom of the web. It is more likely to be seen at a rail end. If it is not at a joint it might be due to manufacturing defects in older rail.</p>		<p>Head of web HW <input type="checkbox"/></p> <p>This crack runs along the top of the web and is dangerous because the head can detach. It is another defect that is more likely to occur at a rail end.</p>
	<p>Split web SW <input type="checkbox"/></p> <p>This defect runs along the center of the web. It is often seen at a weld, as shown in the picture.</p>		<p>Vertical split head VSH <input type="checkbox"/></p> <p>This defect is more common in older rail and when there is a lot of vertical wear.</p>
	<p>Defective field weld DWF <input type="checkbox"/></p> <p>This is easily recognized from the weld metal on the web and base. The fracture usually is very shiny. Often it is possible to see blow holes on the fracture – these show moisture was present when the weld was made.</p>		<p>Engine burn, welded TDW <input type="checkbox"/></p> <p>The dark area towards the top of the head of the rail shows that the break started on the rail top from a weld repair. A break from an engine burn will look just the same. You can tell the two apart by looking to see if there is weld metal on the rail top.</p>
	<p>Transverse fissure TD <input type="checkbox"/></p> <p>This is a break that starts in the center of the head. It is usually found in old rail.</p> <p>Detail fracture TDD, also known as SF <input type="checkbox"/></p> <p>This is a break that starts from a shell at the gage corner of the outer rail in curves. They are not often seen on passenger track.</p>		<p>Engine burn, fracture EBF <input type="checkbox"/></p> <p>Welded bond WB <input type="checkbox"/></p> <p>These cracks start at Cadweld bonds. They have become more common in the last few years. They can be clearly identified by the nearby copper deposits left by bond application.</p>
	<p>Broken base BB <input type="checkbox"/></p> <p>This refers to any break in the base of the rail. In this photograph the crack runs from A to B on top of the rail foot.</p>		<p>Horizontal split head HSH <input type="checkbox"/></p> <p>These also usually occur at a rail end, especially if the rail joint is dipped or if there is a step between the two rails. The horizontal crack can turn up or down in the rail.</p>

Note: When the broken rail is replaced, the damaged section plus 6 inches on either side **must** be cut out and brought to the Track Division's offices **AND** detailed pictures **must** be taken of the broken rail at the field with a label indicating location, track number, and date of break.

Please fill this report in as well as you can. **IT'S IMPORTANT.**



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