2. Standard for Rail Transit Track Inspection and Maintenance

Abstract: This standard provides minimum requirements for inspecting and maintaining rail transit system tracks.

Keywords: fixed structures, inspection, maintenance, rail transit system, structures, track, training, qualifications
Introduction

(This introduction is not a part of APTA RT-FS-S-002-02, *Standard for Rail Transit Track Inspection and Maintenance.*)

APTA rail transit safety standards represent an industry consensus on safety practices for rail transit systems to help achieve a high level of safety for passengers, employees, and the general public. This document was created by and for those parties concerned with its provisions; namely, rail transit systems (operating agencies), OEMs, consultants, engineers, and general interest groups. This standard provides procedures for inspecting and maintaining rail transit tracks.

APTA recommends this standard for:

– Individuals or organizations that inspect, maintain, and/or operate rail transit systems

– Individuals or organizations that contract with others for the inspection, maintenance, and/or operation of rail transit systems

– Individuals or organizations that influence how rail transit systems are inspected, maintained, and/or operated (including but not limited to consultants, designers, and contractors)

This standard intends to meet the following objectives:

– To ensure special life/safety equipment is operational and reliable

– To help rail transit systems 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

The application of any standards, practices, or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of how a rail transit system operates. In such cases, the government regulations override any conflicting practices this document requires or recommends.
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Standard for Rail Transit Track Inspection and Maintenance

1. Overview

This document establishes a standard for the periodic inspection and maintenance of rail transit fixed structure 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 rail transit system (RTS) employees or contractors that perform periodic inspection and maintenance tasks.

1.1 Purpose

The purpose of this standard is to verify that tracks are operating safely and as designed through periodic inspection and maintenance, thereby increasing reliability and reducing the risk of hazards and failures.

1.2 Scope

This standard applies to transit systems and operating entities that own or operate rail transit systems.

1.3 Alternate practices

Individual rail transit systems may modify the practices in this standard to accommodate their specific equipment and mode of operation. APTA recognizes that some rail transit systems may have unique operating environments that make strict compliance with every provision of this standard impossible. As a result, certain rail transit systems may need to implement the standards and practices herein in ways that are more or less restrictive than this document prescribes. An individual RTS may develop alternates to the APTA standards so long as the alternates are based on a safe operating history and are described and documented in the system’s safety program plan (or another document that is referenced in the system safety program plan).

Documentation of alternate practices shall:

a) Identify the specific APTA rail transit safety standard requirements that cannot be met

b) State why each of these requirements cannot be met

c) Describe the alternate methods used
d) Describe and substantiate how the alternate methods do not compromise safety and provide a level of safety equivalent to the practices in the APTA safety standard (operating histories or hazard analysis findings may be used to substantiate this claim).

1.4 References

This document shall be used in conjunction with the most recent version of the following publications:


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

1.5 Definitions and acronyms

For the purposes of this standard, the following definitions and acronyms apply:

1.5.1 Definitions

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

1.5.1.2 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.

1.5.1.3 rail transit system (RTS): The organization or portion of an organization that operates rail transit service and related activities. Syn: operating agency, operating authority, transit agency, transit authority, transit system.

For additional definitions of technical terms used in this document, see Annex A.

1.5.2 Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>APTA</td>
<td>American Public Transportation Association</td>
</tr>
<tr>
<td>AREMA</td>
<td>American Railway Engineering and Maintenance-of-Way Association</td>
</tr>
<tr>
<td>OEM</td>
<td>original equipment OEM</td>
</tr>
<tr>
<td>RTS</td>
<td>rail transit system</td>
</tr>
</tbody>
</table>

1.6 Glossary of terms

Definitions of technical terms used in this document are provided in Annex A.

1.7 Measuring track not under load

When unloaded track is measured to determine compliance with the requirements of these standards, the amount of rail movement if any that occurs while the track is loaded must be added to the measurement of the unloaded track.
1.8 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.

1.9 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.

2. Qualified persons

2.1 Designation of qualified persons

Each RTS or operating entity 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-RTS parties on the rail transit system’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 RTS, as a qualified person shall:

a) Have at least:

   1) Two years of satisfactory related experience inspecting, constructing or maintaining track and special work; and

   2) 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

   3) Have had progressive satisfactory supervisory experience on another transit or railroad system; and,

b) Demonstrate to the RTS that he or she:

   1) Knows and understands the requirements of this standard;

   2) Can detect deviations from these requirements; and
3) Can prescribe appropriate remedial action to correct or safely compensate for those deviations.

A list of qualified persons shall be maintained by the RTS.

3. Inspection

3.1 Track 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. Inspections must be performed by a qualified person as prescribed by Section 2. An interval of at least three but not more than eleven calendar days must elapse between inspections.

b) Non-revenue (yard tracks) shall be inspected once a month.

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 sections 2 and 5. All forms shall be submitted daily for review, file or remedial action. All forms shall be complete and retained on file for a minimum of one year after the date of inspection.

3.2 Rail inspection

Ultrasonic rail flaw detection of mainline track 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. Broken rails must be reported using a standard form. Records shall be maintained for a minimum of two years after inspection and one year after remedial action.

3.3 CWR inspection

Special inspections of 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. In the event daily cycles of extreme temperature fluctuations occur, consideration shall be given to repeated inspections. See Annex C.7.3.

3.4 Geometry inspection

The geometry of mainline standard gauge 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. Rail transit systems with only non-ballasted revenue track shall inspect at least once every two years with an automated track inspection vehicle. This requirement is not applicable to embedded track. See Section 13 for inspection requirements of embedded or street running track.
3.5 Switch and crossing inspection

a) MAIN LINE switches shall be inspected for defects monthly.

b) YARD switches shall be inspected for defects every three months.

c) MAIN LINE and YARD track switches which are signaled or electrically controlled shall be inspected jointly by signal and track forces annually. Joint switch inspection forms shall be used and all information shall be completed for each switch inspected. Track supervision shall be present for this inspection and sign the form. The completed form shall be forwarded to the respective track and signal maintenance managers.

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 ensure the repair is complete.

3.6 Special inspection

In the event of fire, flood, seismic activity, severe storm, or other occurrence, which 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

4.1 Condition reporting

The RTS shall have specific procedures for reporting, corrective action and/or mitigating measures to be taken when track conditions found by qualified personnel deviate from the standards shown herein. Either a track condition prioritization system or a speed-based track classification system shall be used. In either case, operations over deficient track conditions shall not be allowed to exceed the prescribed minimum safety requirements indicated herein.

4.2 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 RTS must be utilized.

4.3 Classes of track

If a speed-based track classification system is used by the RTS, it 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

<table>
<thead>
<tr>
<th>Over track that meets all of the requirements prescribed herein</th>
<th>Maximum allowable train speed (miles per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>90</td>
</tr>
</tbody>
</table>

NOTE –

1-The designated operating speeds of some transit systems may be determined by designed automatic train control systems or through established operating practices. The RTS may alter the maximum allowable train speeds in this table to match their 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.

4.4 Condition prioritization

If a condition prioritization system is used by the RTS, it shall conform to the following:

   a) The condition prioritization system shall be as described in Table 2; and

   b) Any RTS 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

<table>
<thead>
<tr>
<th>Priority</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>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, the person(s) making the decision must not leave the scene until relieved or until the defect is repaired. When &quot;walking&quot; 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 &quot;Restricted Speed with Extreme Caution&quot;; 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.</td>
</tr>
<tr>
<td>2</td>
<td>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.</td>
</tr>
<tr>
<td>3</td>
<td>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.</td>
</tr>
<tr>
<td>4</td>
<td>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.</td>
</tr>
</tbody>
</table>

NOTE:
1—The RTS may modify the above prioritization code to meet its individual requirements; however modifications shall be:

A) Consistent with the above table, and

B) Uniformly applied throughout the rail transit system’s maintenance standards.

5. Corrective action

5.1 Scope of section

This Section describes the methods and systems that the RTS shall apply when it knows, or has notice, that the track does not comply with the requirements specified herein.
5.2 Required action

Any RTS who 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 priority 1 movements shall be under the continuous supervision of a qualified person, subject to conditions set forth herein, at an appropriate restrictive speed not to exceed 15 miles per hour; or

c) Halt operations over that track.

5.3 Conditions detected by automated track inspection vehicles

Conditions detected by automated track inspection vehicles shall be classified according to the designations shown above. A qualified person shall perform the analysis and interpretation of those conditions, as well as any determination regarding the required corrective action, if any. 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, the prescribed action(s) shall be taken.

6. Roadbed

6.1 Scope of section

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

6.2 Drainage

Drainage is an important component 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 water flow.

6.2.1 High water conditions

High water conditions in track shall restrict train operations as shown in Table 3.
### Table 3-High Water Condition

<table>
<thead>
<tr>
<th>Class Of Track</th>
<th>Priority</th>
<th>Operating Speed</th>
<th>High Water Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>15 MPH or Less</td>
<td>Within the head of either running rail¹</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>16 to 30 MPH</td>
<td>Above the base of either running rail</td>
</tr>
<tr>
<td>3 through 5</td>
<td>3</td>
<td>31 to 90 MPH</td>
<td>Up to the base of either rail</td>
</tr>
</tbody>
</table>

**NOTE:**
1 - Only supervised operation is permitted where water is above the running surface of either rail.
2 – This table is not applicable for street running trackwork. Rail transit systems with street running track shall develop and adhere to specific guidelines for their conditions.

### 6.3 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:

a) Become a fire hazard;

b) Obstruct visibility of signs and signals;

c) Interfere with employees performing normal trackside duties;

d) Prevent proper functioning of signal and communication lines;

e) Prevent employees from visually inspecting moving equipment from their normal duty stations; or

f) Strike or rub the sides or tops of trains.

### 6.4 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 the 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 interfere with:

a) Possible evacuation of passengers and personnel in an emergency;

b) Possible actions of emergency personnel;
c) Come in contact with rail vehicles;

d) Operation of train control systems;

e) Operation of switches and special trackwork;

f) Operation of moveable bridges;

g) Traction Power distribution systems; and

h) Contact the running or guard rails.

In addition to that shown above, 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

7.1 Scope of section

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

7.2 Lift rails

Lift rails at moveable bridges shall be closely monitored. They are subject to all applicable standards included in this document, and must be inspected monthly. During inspection, check that all fasteners are secure and holding. Check for proper lubrication, unusual wear, over-flow, mismatched joints, and cracks in casting.

7.3 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.

7.4 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.

7.5 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 they should be inspected monthly.
8. Track geometry

8.1 Scope of section

This Section prescribes the requirements for gauge, horizontal alignment, surface and super-elevation of track.

8.2 Track gauge

8.2.1 Gauge

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

8.2.2 Gauge limits

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

Table 4-Track gauge limits

<table>
<thead>
<tr>
<th>Class of track</th>
<th>Priority</th>
<th>Operating speed</th>
<th>Track gauge limits(^1) deviation from design(^2)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>15 MPH OR LESS</td>
<td>-1/2”(^3)</td>
<td>+1 1/2” (^4)</td>
<td></td>
</tr>
<tr>
<td>2 and 3</td>
<td>2</td>
<td>16 to 60 MPH</td>
<td>-1/2”</td>
<td>+1 1/4”</td>
<td></td>
</tr>
<tr>
<td>4 and 5</td>
<td>3</td>
<td>61 to 90 MPH</td>
<td>-1/2”</td>
<td>+1”</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1) This table is intended for rail transit systems using American Association of Railroads (AAR) standard wheels, regardless of the design track gauge. If non-standard wheels are used the RTS shall perform a special evaluation of their specific conditions and set appropriate limits, subject to the conditions shown in Section 1.4 above.

2) Where gauge varies by design, for example because of sharp horizontal curvature or to reduce truck hunting on tangent, then that designed gauge shall be used to determine the allowable deviations specified above. These adjustments to track gauge shall be clearly designated in the RTS standards.

3) No operation is permitted when loaded gauge deviation is tighter than -1/2”.

4) No operation is permitted when loaded gauge deviation is more than +1 1/2”.
8.3 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 gauge 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>
<thead>
<tr>
<th>Class of Track</th>
<th>Priority</th>
<th>Operating Speed</th>
<th>Maximum Allowable Deviation From Design Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tangent Track</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>31' Chord</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>15 MPH OR LESS</td>
<td>3”</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>16 to 30 MPH</td>
<td>3”</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>31 to 60 MPH</td>
<td>1 1/4”</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>61 to 80 MPH</td>
<td>1”</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>81 to 90 MPH</td>
<td>1/2”</td>
</tr>
</tbody>
</table>

8.4 Track surface

Rail transit systems shall maintain the surface of its track within the limits prescribed in Table 6. For rail transit systems with speeds enforced by train control systems see Annex B for corresponding track surface deviation limits.
### Table 6-Track surface

<table>
<thead>
<tr>
<th>Class Of track:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority:</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operating speed:</th>
<th>15 MPH or less</th>
<th>16 to 30 MPH</th>
<th>31 to 60 MPH</th>
<th>61 to 80 MPH</th>
<th>81 to 90 MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition description</td>
<td>Chord length or distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runoff in any 31 feet of rail at the end of a raise may not be more than</td>
<td>31’</td>
<td>3 1/2”</td>
<td>3”</td>
<td>2”</td>
<td>1 1/2”</td>
</tr>
<tr>
<td>Deviation from uniform profile</td>
<td>31’ chords</td>
<td>1”</td>
<td>3/4”</td>
<td>1/2”</td>
<td>3/8”</td>
</tr>
<tr>
<td>Deviation from constant cross level</td>
<td>62’ chords</td>
<td>3”</td>
<td>2 3/4”</td>
<td>2 1/4”</td>
<td>2”</td>
</tr>
<tr>
<td>Deviation from desired elevation in spirals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in constant cross level between 2 points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variation in cross level in spirals between 2 points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE** –
1. Either a 31’ or 62’ chord length or distance may be designated to be used by an RTS. However, the same chord length shall be exclusively used when applying this table.
2. Refer to Section 1.4 exceptions

### 8.5 Super-elevation

Curved track shall be super-elevated in accordance with each rail transit system’s standards and maintained within the limits described in Table 6.

### 8.6 Super-elevation runoff

Super-elevation runoff shall be at a uniform rate, within the limits of track surface deviation prescribed in Table 6. Super-elevation 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, part of the runoff may be on adjacent tangent or curve. If the super-elevation is run off within the curve, the minimum super-elevation in the curve shall be used to calculate the maximum operating speed. If the super-elevation is run off in adjacent tangent, the maximum cross-level on tangent track shall not exceed that shown in Table 6.

8.7 Determination of super-elevation

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

8.8 Horizontal curve data

Each RTS 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, super-elevation, 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.

9. Track structure

9.1 Scope of section

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

9.2 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;

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.

9.3 Rail fastener requirements

9.3.1 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 gauge and alignment, preventing excessive horizontal and vertical movement and transmitting 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 gauge, 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 7.

d) The number of consecutive ineffective rail fasteners shall not be more than that prescribed in Table 8.

**Table 7-Minimum number of non-defective rail fasteners for any 39-ft. length of rail**

<table>
<thead>
<tr>
<th>Class of track</th>
<th>Operating speed</th>
<th>Priority</th>
<th>Minimum effective for any 39’ of rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Less than 15 Mph</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2 and 3</td>
<td>16 to 60 Mph</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>4 and 5</td>
<td>61 to 90 Mph</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

**Table 8-Maximum number of consecutive defective rail fasteners per 39-ft. length of rail**

<table>
<thead>
<tr>
<th>Class of track</th>
<th>Operating speed</th>
<th>Priority</th>
<th>Tangent and curves with radii at or over 2000 feet</th>
<th>Curves with radii between 1000 and 2000 feet</th>
<th>Curves with radius of less than 1000 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>Less Than 30 MPH</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>31 to 60 MPH</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4 and 5</td>
<td>61 to 90 MPH</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

**9.3.2 Timber crossties**

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

a) There are less than 2 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; or

b) The crosstie is broken through; or

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 the tie will allow the ballast to work through;

e) The crosstie is plate-cut more than 1 inch;

f) The crosstie is deteriorated such that the tie plate or base of rail can move laterally more than ½ inch relative to the crosstie.
9.3.3 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; or

d) The tie is broken.

9.3.4 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; or

e) The concrete supporting the fastener is deteriorated or impaired such that it does not provide proper support.

9.4 Clearances

a) Each RTS must develop a Right-of-Way Clearance Diagram based upon the car and line equipment dynamic envelopes. Right-of-Way Clearance Envelopes cannot be violated without the approval of the agencies Chief Engineer or equivalent. 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 in, or in the vicinity of the tracks.

b) Before commencing 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

10.1 Scope of section

This Section prescribes the requirements for the maintenance of rail.

10.2 Defective rails

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

10.2.1 Knowledge of defective rails

Agencies who know or have notice that a rail in track contains any of the defects listed in Table 9 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 action described in Tables 9A, 9B and 9C.

10.2.2 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 through the location of the defect;

d) At welds, if joint bars are used to protect rail defects, 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 and 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; and,

e) If a rail defect is found in the wing or heel rails of a frog, the existence of two frog bolts on both sides of the defect may be considered the same as joint bars.

10.2.3 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 Tables 9A, 9B and 9C:

a) Where remedial actions C, D, or E given in the notes for Table 9C require the use of joint bars, and joint bars cannot be placed due to the physical configuration of the switch, remedial action B will govern, provided there are reinforcing bars on the both sides of the switch point and 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.

10.2.4 Definition of rail defects

Rail transit systems shall use the definitions of defects shown herein.

10.2.5 Definition of transverse defect size

Rail transit systems may either use percent of cross-sectional area or a size designation for determining appropriate remedial action on transverse defects as shown in Table 9A, 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 rail transit system’s standards.

10.2.6 Torch cut rails

Torch-cut rail ends shall only be used in an emergency. If used in the mainline tracks, torch-cut rails must be replaced as soon as practicable and protected with a slow speed order under supervision until replaced.

10.2.7 Required action

Rail transit systems shall either replace rail or at a minimum, perform the action(s) shown in Table 9.
<table>
<thead>
<tr>
<th>Type of transverse rail defect</th>
<th>Rail head cross-sectional area weakened by defect</th>
<th>Priority</th>
<th>Minimum remedial action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added</td>
<td>Greater than</td>
<td>Less than</td>
<td>2</td>
</tr>
<tr>
<td>Transverse fissure</td>
<td>2</td>
<td>1</td>
<td>A2</td>
</tr>
<tr>
<td>Compound fissure</td>
<td>2</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>Detail fracture</td>
<td>2</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>Engine burn fracture</td>
<td>2</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>Defective weld</td>
<td>3</td>
<td>2</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A2 or both E &amp; H</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A or both E &amp; H</td>
</tr>
<tr>
<td>Type of longitudinal rail defect</td>
<td>Longer than</td>
<td>Shorter than</td>
<td>Priority</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------</td>
<td>--------------</td>
<td>----------</td>
</tr>
<tr>
<td>Horizontal split head</td>
<td>1”</td>
<td>2”</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2”</td>
<td>4”</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4”</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Break out in rail head</td>
<td>1</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Vertical split head</td>
<td>1”</td>
<td>2”</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2”</td>
<td>4”</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4”</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Break out in rail head</td>
<td>1</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Split web</td>
<td>1”</td>
<td>2”</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2”</td>
<td>4”</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4”</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Break out</td>
<td>1</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Piped rail</td>
<td>1”</td>
<td>2”</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2”</td>
<td>4”</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4”</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Break Out</td>
<td>1</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Head web separation</td>
<td>1”</td>
<td>2”</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2”</td>
<td>4”</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4”</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Break out</td>
<td>1</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Bolt hole crack</td>
<td>1/2”</td>
<td>1”</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>1”</td>
<td>1 1/2”</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1 1/2”</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Break out</td>
<td>1</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>
### Table 9B-Rail defect remedial action

<table>
<thead>
<tr>
<th>Type of longitudinal rail defect</th>
<th>Longer than</th>
<th>Shorter than</th>
<th>Priority</th>
<th>Minimum remedial action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broken base</td>
<td>1”</td>
<td>6”</td>
<td>2</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>6”</td>
<td>-</td>
<td>1</td>
<td>A or both E &amp; I</td>
</tr>
</tbody>
</table>

### Table 9C-Rail defect remedial action

<table>
<thead>
<tr>
<th>Other rail defects</th>
<th>Depth</th>
<th>Size</th>
<th>Priority</th>
<th>Minimum remedial action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flattened rail</td>
<td>Greater than or equal to 3/8”</td>
<td>Greater than or equal to 8”</td>
<td>2</td>
<td>H</td>
</tr>
<tr>
<td>Ordinary break</td>
<td>N/A</td>
<td>Any</td>
<td>1</td>
<td>A or E</td>
</tr>
<tr>
<td>Damaged rail</td>
<td>N/A</td>
<td>Any</td>
<td>2</td>
<td>D</td>
</tr>
<tr>
<td>Corroded rail</td>
<td>Loss of metal at base of rail</td>
<td></td>
<td>2</td>
<td>K</td>
</tr>
<tr>
<td>Short wave rail corrugation</td>
<td>Over 1/8” deep</td>
<td></td>
<td>2</td>
<td>Grind rail</td>
</tr>
</tbody>
</table>

Notes:

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, 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 continue 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, the operating speed shall be limited to 60 MPH, for a period not to exceed 4 days. If the defective rail has not been removed from the track or a permanent repair made within 4 days of the discovery, 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 to continue the track in use by qualified person. 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 continue the track in use with a maximum operation speed of 30 MPH or less as authorized by a by qualified person. After joint bars are applied, limit speed to 60 MPH or less as authorized by a by qualified person.
E. Apply joint bars.

F. Qualified person to re-inspect rail within three months after it is determined to continue the track in use.

G. Qualified person to re-inspect rail within one month days after it is determined to continue the track in use.

H. Limit operating speed over defective rail to no more that 60 MPH or less as determined by qualified person.

I. Limit operating speed over defective rail to no more that 30 MPH or less as determined by qualified person.

J. Limit operating speed over defective rail as determined by qualified person.

K. Base corroded rails shall be inspected and verified by track supervision, and replaced within 90 days of their detection. The track supervision shall perform an inspection of the base corroded rails at least once a week. If any priority track geometry defects are found at the base corroded rail location, the rail shall be replaced as soon as possible and the defect corrected immediately.

10.3 Rail wear

Rail wear limits should be established by each RTS based on rail section and wheel flange dimension. A recommended practice for 115RE rail with standard AAR wheels is provided in Annex D as a guide.

10.3.1 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.

10.4 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.

10.4.1 Rail joints

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

b) If a joint bar on Classes 3 through 5 track is cracked, broken, or because of wear allows excessive vertical movement of either rail when all bolts are tight, it shall be replaced.

c) If a joint bar is cracked or broken between the middle two boltholes it shall be replaced.

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 5 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 (4) 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 bolthole that is torch cut or burned in Classes 2 through 5 track.

  h) No joint bar shall be reconfigured by torch cutting in Classes 2 through 5 track.

10.4.2 Rail ends

Rail ends shall be maintained as described herein.

10.4.2.1 Rail end mismatch

Gauge face mismatch shall be measured at the gauge 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 10.

<table>
<thead>
<tr>
<th>Class of track</th>
<th>Operating speed</th>
<th>Priority</th>
<th>Tread mismatch</th>
<th>Gauge face mismatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Less than 15 MPH</td>
<td>1</td>
<td>1/4”</td>
<td>1/4”</td>
</tr>
<tr>
<td>Class 2</td>
<td>16 to 30 MPH</td>
<td>2</td>
<td>1/4”</td>
<td>3/16”</td>
</tr>
<tr>
<td>Class 3</td>
<td>31 to 60 MPH</td>
<td>3</td>
<td>3/16”</td>
<td>3/16”</td>
</tr>
<tr>
<td>Classes 4 and 5</td>
<td>61 to 90 MPH</td>
<td>4</td>
<td>1/8”</td>
<td>1/8”</td>
</tr>
</tbody>
</table>

10.4.2.2 Rail end batter

Rail end batter shall not exceed that shown in Table 11.
Rail end batter shall not exceed that shown in Table 11.

**Table 11-Rail end batter**

<table>
<thead>
<tr>
<th>Class of track</th>
<th>Operating speed</th>
<th>Priority</th>
<th>Tread mismatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Less than 15 MPH</td>
<td>1</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>Class 1</td>
<td>16 to 30 MPH</td>
<td>2</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>Class 3</td>
<td>31 to 60 MPH</td>
<td>3</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>Class 4</td>
<td>61 to 80 MPH</td>
<td>4</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>Class 5</td>
<td>81 to 90 MPH</td>
<td>4</td>
<td>1/16&quot;</td>
</tr>
</tbody>
</table>

**10.5 Continuous welded rail (CWR)**

**10.5.1 Procedures**

Each RTS with track constructed of CWR shall have in effect and comply 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, that shown herein.

a) Procedures for the installation of CWR that include:

1) Designation of a desired rail installation temperature range for the geographic area in which the CWR is located; CWR should be laid when the rail temperature is within the temperature range specified by the following equations:

   Minimum \( D.R.T. = \frac{(2Ht + Lt)}{3} + 10 \)

   Maximum \( D.R.T. = \frac{(2Ht + Lt)}{3} + 25 \) ± 5

   Where

   \( D.R.T. \) is the Desired Rail Temperature

   \( Ht \) is the Highest Rail Temperature

   \( Lt \) is the Lowest Rail Temperature

2) 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) 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:

1) 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

2) Under no circumstances should rail be added when the rail temperature is below that designated in 10.5.1.a) 1) herein, without provisions for later adjustment.

d) 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.

e) Procedures that control train speed on CWR track when:

1) Maintenance work, track rehabilitation, track construction, or any other event occurs which disturbs the roadbed or ballast section and reduces the lateral or longitudinal resistance of the track; and

2) In formulating the procedures under this paragraph, the RTS shall:

   i) 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 re-consolidation to stabilize the track to a level that can accommodate expected train-induced forces. Ballast re-consolidation can be achieved through either the passage of train tonnage or mechanical stabilization procedures, or both; and

   ii) Take into consideration the type of fasteners used.

f) 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:

1) Locations where tight or kinked rail conditions are likely to occur;

2) Locations where track work of the nature described in Annex C.5.3 have recently been performed; and

3) In formulating the procedures under this paragraph, the RTS shall:

   i) Specify the timing of the inspection; and
ii) Specify the appropriate remedial actions to be taken when buckling prone conditions are found.

g) Agencies shall have in effect a comprehensive training program for the application of these written CWR procedures, with provisions for periodic re-training, for those individuals designated as qualified herein.

h) Agencies shall prescribe record-keeping requirements necessary to provide an adequate history of track constructed with CWR. At a minimum, these records must include:

1) Rail temperature, location and date of CWR installations or adjustments. This record shall be retained for at least one year; and

2) 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.

### 10.5.2 Inspection of CWR

When inspecting CWR, the following areas are to 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.
10.5.3 Maintaining and working CWR track

Before performing trackwork 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 Annex C for further discussion of trackwork that constitutes disturbed track and CWR maintenance practices.

11. Restraining (guard) rails on regular track

11.1 Scope of section

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

11.2 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 12.

<table>
<thead>
<tr>
<th>Class of track</th>
<th>Operating speed</th>
<th>Priority</th>
<th>Double guarding restraining rails guard face gage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Less than 15 MPH</td>
<td>1</td>
<td>+1/2”</td>
</tr>
<tr>
<td>2, 3 and 4</td>
<td>16 to 80 MPH</td>
<td>2</td>
<td>+3/8”</td>
</tr>
<tr>
<td>5</td>
<td>81 to 90 MPH</td>
<td>2</td>
<td>+1/4”</td>
</tr>
</tbody>
</table>

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

11.3 Restraining rail maintenance standards

Rail transit systems shall specifically designate in their maintenance standards those maintenance requirements regarding the maintenance, application and use of restraining rails used for guarding purposes. The following shall be included:

a) Where restraining rails are specifically required for the safe operations;

b) A specific procedure concerning the partial and complete removal of restraining rails;

c) Specific operating restriction(s), if any, required for the partial and complete removal of restraining rails;

d) Specific procedures, including mitigative measures and necessary operating restriction, required when breaks in restraining rails are found;
e) Specific procedures and allowable limits, including mitigative measures and necessary operating restriction, where broken or otherwise ineffective restraining rail fasteners are known to exist;

f) Specific numeric table(s) describing the allowable amounts of flare and flare length at the ends of restraining rails, including mitigative and required operating restriction; and,

g) Specific numeric table(s) for describing the allowable flange-way widths on restraining rails, including mitigate measures and required operating restriction

h) In no case shall the minimum flange-way width on restraining rails be allowed to be less than 1 1/2”, except as provided for in Section 11.2 herein. Refer to Section 1.3 for exceptions.

12. Special trackwork

12.1 Scope of section

In turnouts and track crossings, fastenings shall be intact and maintained so as 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.

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 1 1/2”. Refer to Section 1.3 for exceptions.

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 over tightening 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 (A.R.E.M.A 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 inches of the point should not be visible when looked at from above, and must not be higher, under any circumstances, than the top of the stock rail. Any signs of unusual wear on the first 6 inches 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.
Immediate protection and prompt corrective action are necessary when a switch point is found to stand open against its stock rail.

c) Any lip formation on the gauge 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.

d) 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 gauge side of the stock rail.

e) The heel of each switch point must be secure, and the bolts in each heel must be kept tight.

f) Each switch stand and connecting rod must be securely fastened and operable without excessive lost motion.

g) Each hand throw lever must be maintained so that it cannot be operated while the lock is in the keeper.

h) Each switch position indicator must be clearly visible at all times.

i) 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 ¼ inch). 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.

12.2.1 Special design switches

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 3/8”;

b) Where operating speeds exceed 15 MPH the Flange-way depth shall not be less than 1 1/2”; and,

c) Where frogs are designed as flange-bearing, the flange-way depth may be less than the minimum shown herein; however, the operating speed may not exceed an appropriate restrictive speed not greater than 15 miles per hour.
12.3.2 Damaged frogs

a) If a frog point is chipped, broken, or worn more than five-eighths inch down and 6 inches back, operating speed over the frog shall not exceed 10 MPH.

b) If the tread portion of a frog casting is worn down more than three-eighths inch below the original contour, operating speed over that frog shall not exceed 10 MPH.

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 1/4”.

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 three-eighths of an inch.

b) If repairs are made to a self-guarded frog without removing it from service, the guarding face shall be restored before rebuilding the point.

12.4 Guard rail gauges in frogs

The guard check and guard face gauges in frogs shall be within the limits prescribed in Table 13.

<table>
<thead>
<tr>
<th>Class of track</th>
<th>Operating speed</th>
<th>Priority</th>
<th>Guard check gauge shall not be tighter than</th>
<th>Guard face gauge shall not be greater than</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Less than 15 MPH</td>
<td>1</td>
<td>-1/2”</td>
<td>+1/2”</td>
</tr>
<tr>
<td>2</td>
<td>16 to 30 MPH</td>
<td>2</td>
<td>- 3/8”</td>
<td>+3/8”</td>
</tr>
<tr>
<td>3 and 4</td>
<td>31 to 80 MPH</td>
<td>2</td>
<td>- 1/4”</td>
<td>+3/8”</td>
</tr>
<tr>
<td>5</td>
<td>81 to 90 MPH</td>
<td>3</td>
<td>- 1/8”</td>
<td>+1/4”</td>
</tr>
</tbody>
</table>
12.5 Working on special work

Any trackwork 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 trackwork 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 trackwork

13.1 Scope of section

This Section describes the inspection and minimum requirements that are 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 these Standards govern. Street running track is commonly referred to as embedded track or paved track.

13.2 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 can not 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 eleven calendar days may elapse between inspections.

b) Tongue and mate switches are to be inspected weekly with at least three but not more than eleven calendar days between inspections.

13.3 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 which are only peripherally related to track inspection and track maintenance, but which 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.

a) Debris in the vicinity of track, particularly in the flange-way and the area of track special work.

b) 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.

c) Street surface higher than the top of rail that could result in equipment being stuck or damaged.
d) 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.

e) Undermined track.

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

a) Loose cobble stones, pavers, or bricks

b) Pot holes

c) Low paving around rails

13.4 Track geometry

13.4.1 Gauge

Measurements for track gauge on girder and tram rail may vary from that outlined in Section 8.2. In the event a different measurement for gauge is used, the RTS shall document this measurement and the corresponding gauge tolerances unique to their specific design, subject to the conditions of section 1.3.

13.4.2 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 insure that rail-wear does not create a flange-bearing condition. Any obstructions to the flange-way should be removed as soon as possible. If part of the track structure (i.e. elasto-meric booting, rubber material, asphalt, or concrete, etc.) has begun to obstruct or diminish the depth of the flange-way, 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.

13.5 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 gauge, alignment and profiles described in sections 8, 10, 11, 12 and herein are found, repair of supporting structure shall be performed to correct the defects.

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 there is not encroachment to the dynamic envelope of the vehicle.
13.6 Rail

13.6.1 Rail defects

If conditions listed below are found, a qualified person is to identify the conditions on the track inspection report and perform the action(s) shown in Table 14.

Table 14-Rail defect remedial action

<table>
<thead>
<tr>
<th>Type rail defect</th>
<th>Longer than</th>
<th>Shorter than</th>
<th>Priority</th>
<th>Minimum remedial action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broken rail on guard – no movement</td>
<td>Not applicable</td>
<td>3</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Broken rail on guard – movement/ pumping</td>
<td>Not applicable</td>
<td>3</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Missing head/rail breakout</td>
<td>1”</td>
<td>2”</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>2”</td>
<td>4”</td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>4”</td>
<td>-</td>
<td>1</td>
<td>D</td>
</tr>
<tr>
<td>Cracked rail joint/ weld area</td>
<td>1”</td>
<td>4”</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>4”</td>
<td>-</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>Guard breakout</td>
<td>0”</td>
<td>1”</td>
<td>3</td>
<td>C, A</td>
</tr>
<tr>
<td>Cracked broken tram</td>
<td>Any size</td>
<td>Any size</td>
<td>3</td>
<td>F</td>
</tr>
</tbody>
</table>

NOTES –

A) Qualified person to re-inspect every 7 days.

B) Limit operating speed over defective area to no more than 20 mph or less as determined by qualified person.

C) Limit operating speed over defective area to no more than 5 mph and repair within 24 hours.

D) Track is to be placed out of service or operations are to continue only under the supervision of a qualified person.

E) Qualified person is to re-inspect area daily and repair to be completed within 7 days.

F) Schedule repair as severity warrants.

13.6.2 Rail wear

Rail gauge face wear, head width and vertical wear shall be measured at the gauge line, etc. as appropriate for the rail transit system’s particular rail section. Limits for rail wear on girder and tram rail shall be established based on rail section and wheel flange depth.

13.7 Special trackwork

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

For flange-bearing areas of special work each transit RTS shall develop maximum flange-way
wear limits. Programmed action (build-up of the frog flange-way) is required if wear exceeds the limit or special work exhibits signs of excessive contact with the wheel thread.

All non-flange-bearing parts of street special work will be maintained to have a flange-way as described in section 13.4.2.

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 take-off 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 rail head 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 perform the action(s) shown in Table 15.

**Table 15-Tongue and mate switch conditions**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Required action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tongue vertical wear</td>
<td></td>
</tr>
<tr>
<td>3/16” below casting</td>
<td>Schedule for replacement</td>
</tr>
<tr>
<td>¼” below casting</td>
<td>Replace within 30 days</td>
</tr>
<tr>
<td>Sharp edge</td>
<td>Grind within 7 days to restore contour</td>
</tr>
<tr>
<td>Loose heel</td>
<td>Schedule to retighten within 3 days</td>
</tr>
<tr>
<td>Mate false grooves</td>
<td></td>
</tr>
<tr>
<td>Over 3/16”</td>
<td>Repair within 7 days</td>
</tr>
<tr>
<td>Split through risers</td>
<td>Repair within 24 hours</td>
</tr>
<tr>
<td>Wheel cuts in switch casting</td>
<td></td>
</tr>
<tr>
<td>3/16”</td>
<td>Repair within 30 days</td>
</tr>
</tbody>
</table>
Annex A

(Informative)

Glossary of terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>adzing machine</td>
<td>Portable, power-operated machine designed to adze the rail seat on ties to provide proper bearing for rail or tie plates.</td>
</tr>
<tr>
<td>aerial structure</td>
<td>Any system structure that carries transit tracks and spans above land or water surfaces.</td>
</tr>
<tr>
<td>alarm condition</td>
<td>Any abnormal condition that requires the attention or intervention of responsible personnel or an individual monitoring the transit system operation.</td>
</tr>
<tr>
<td>alignment</td>
<td>The horizontal location of track as described by curves and tangents.</td>
</tr>
<tr>
<td>anchor, back-up</td>
<td>A rail anchor applied to control rail movement during anchoring procedures.</td>
</tr>
<tr>
<td>anchor bolt</td>
<td>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.</td>
</tr>
<tr>
<td>anchor, box</td>
<td>Four rail anchors on the running rails at one tie with two anchors on each rail, one on each side of the tie.</td>
</tr>
<tr>
<td>anchor, contact rail</td>
<td>An insulated assembly attached to the contact rail and invert or ties to retain the rail against thermal movement in the longitudinal direction.</td>
</tr>
<tr>
<td>anchor, rail</td>
<td>A track appliance designed to resist longitudinal rail movement due to traffic and temperature variations.</td>
</tr>
<tr>
<td>frog angle</td>
<td>The angle formed by intersection gauge lines of a frog.</td>
</tr>
<tr>
<td>switch angle</td>
<td>The angle between the gauge lines of the switch rail at its point and the stock rail.</td>
</tr>
<tr>
<td>approach slab</td>
<td>A concrete slab located at an aerial structure abutment or tunnel portal, to provide a transition from direct fixation track to ballasted track.</td>
</tr>
<tr>
<td>area</td>
<td>American Railway Engineering Association, predecessor to AREMA.</td>
</tr>
<tr>
<td>AREMA</td>
<td>American Railway Engineering and Maintenance-of-Way Association.</td>
</tr>
</tbody>
</table>
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

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 joint less audio frequency track circuits to couple inductively and confine the signaling energy to its own track circuit and 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 where the elasto-meric 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 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 bold 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 etc.

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 where 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.

clearances  The distance between specified points along the tracks and specified pints on moving vehicles.

clip  See elastic rail clip, rigid rail clip.

closure rails  The rail between the switch and the frog in a turnout.

compound fissure  A progressive fracture originating in a horizontal split head which turn 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 which 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 butt-welded together into various lengths.

**control cooled** 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 actions, either regularly or slowly as by rusting, or irregularly and rapidly as pitting and grooving in the interior of boilers.

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

**coverboard** A fiberglass cover over the contact rail to protect personnel from accidental contact with the rail.

**coverboard bracket** A fiberglass bracket attached to the base of the contact rail to support the coverboard.

**creosote** As used in wood preserving, creosote is 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 257deg. F beginning at about 392 deg 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.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>cross-level</td>
<td>The vertical relationship of the top of one running rail to that of the</td>
</tr>
<tr>
<td></td>
<td>opposite running rail at any point in the track.</td>
</tr>
<tr>
<td>crossing at grade</td>
<td>An intersection of two or more tracks at the same elevation.</td>
</tr>
<tr>
<td>crossover</td>
<td>Two turnouts with track between, connecting two nearby and usually</td>
</tr>
<tr>
<td></td>
<td>parallel tracks.</td>
</tr>
<tr>
<td>crushed head</td>
<td>A flattening or crushing down of the head of a rail.</td>
</tr>
<tr>
<td>current, foreign</td>
<td>Stray electrical currents which may affect a signaling system, but</td>
</tr>
<tr>
<td></td>
<td>which are not a part of the system.</td>
</tr>
<tr>
<td>current, leakage</td>
<td>An electric current that flows through or across the surface of</td>
</tr>
<tr>
<td></td>
<td>insulation when a voltage is impressed across the insulation.</td>
</tr>
<tr>
<td>curve, circular</td>
<td>A horizontal curve specified by radius or degree of curve.</td>
</tr>
<tr>
<td></td>
<td>P.C. Point of Curve.</td>
</tr>
<tr>
<td></td>
<td>P.T. Point of Tangent.</td>
</tr>
<tr>
<td>Spiral Curve</td>
<td>A transition curve connecting a tangent to a circular curve.</td>
</tr>
<tr>
<td>S.T. Spiral to Tangent</td>
<td>T.S. Tangent to Spiral</td>
</tr>
<tr>
<td>Vertical Curve</td>
<td>A parabolic curve connecting different profile grades.</td>
</tr>
<tr>
<td>cut and cover</td>
<td>A method of constructing an underground structure, mostly tunnels,</td>
</tr>
<tr>
<td></td>
<td>by excavating from the surface, placing the structure, and then</td>
</tr>
<tr>
<td></td>
<td>backfilling and restoring the original surface.</td>
</tr>
<tr>
<td>cwr</td>
<td>Continuous welded rail.</td>
</tr>
<tr>
<td>dap</td>
<td>A recess cut into a tie.</td>
</tr>
<tr>
<td>de-energize</td>
<td>To deprive an electro-receptive device of its operating current.</td>
</tr>
<tr>
<td>degradation</td>
<td>Falling from an initial level to a lower level in quality or</td>
</tr>
<tr>
<td></td>
<td>performance.</td>
</tr>
<tr>
<td>depth</td>
<td>The depth of the wheel flange passageway, or the vertical distance</td>
</tr>
<tr>
<td></td>
<td>from the top of the tread portion and guard portion of a track</td>
</tr>
<tr>
<td></td>
<td>structure.</td>
</tr>
<tr>
<td>derail</td>
<td>A device designed to cause rolling equipment to leave the rails.</td>
</tr>
<tr>
<td>derailment</td>
<td>The condition of rolling equipment leaving the rails.</td>
</tr>
</tbody>
</table>
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:

- Shell where a thin shell of metal becomes separated from the head, usually at the gauge corner.
- Head checks usually at or close to the gauge 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 which 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 which 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 railfastener  
A sub-category of elastic fastener where the rail fastener attaches immediately to a rigid support (concrete, invert, concrete deck, floating slab, open deck structure). Direction fixation systems are systems that do not use ballast. Resilient Fasteners and embedded concrete blocks with elastomeric boots (embedded in invert concrete pockets) are 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.

Double  
A combination of a crossing with two right hand and two left hand switches and curves between them within the limits of the crossing
and connecting the two intersecting tracks on both sides of the crossing and without the use of separate turnout frogs.

**Dress**
To shape and trim the ballast to the required cross section.

**Elastic fastener system**
Any rail fastening system that includes an elastic rail clip. This term encompasses a broad class of track fastener systems (many of which are not direct fixation systems) and is often a source of confusion (and miscommunication) where the intent is to refer to more specific components or types of components. Ambiguity frequently occurs between this term and resilient fastener, direct fixation fastener, bonded fastener, and 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 1,000 foot intervals to accommodate thermal expansion and contraction of the rail.

**Elastomer plate**
(See BONDED FASTENER).

**Embedded wood block systems (in concrete inverts)**
This type of system may be a direct fixation system because it “fits” the definition. However, this system does not necessarily require an elastic rail clip (and usually does not). This is a compromise system that defies narrow definition. However, its successful longevity (well over 50 years in Chicago tunnels without maintenance) requires its inclusion in our thinking.

**End chipping**
The loosening of metal at the top of gauge 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. The terminology is inherently confusing because the rail support component of may Direct Fixation Fastener systems can be bonded or un-bonded (elastomer sheet sandwiched between steel plates). The use of other terms to refer to the fastener body is frequent, such as elastic fastener and resilient fastener. While the local terminology refers to specific designs that are reasonably understood by constituents within a specific agency, caution in these terms is useful in limiting interpretation permutations when dealing in contracts, outside engineers and others external to the agency.

**Fastener vertical spring rate**

\[ K = \left( \frac{Ec}{t} \right) \]

- **K**= Compression Spring Rate
- **Ec**= Compression modulus of elastomer
- **A**= Projected load areas of elastomer.
- **T**= elastomer thickness.

**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.

**Flagmen**
Personnel assigned to control movement of train by the display of hand signals, flags or lights.

**Flangeway**
The open way through a track structure which 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 towards the sides without showing any indication of breaking down of the head structure.

**Fouling point**
The location on a turnout, back of the frog, at which insulated joints or derails are placed at or beyond the clearance point.
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.

frog, track  Track structure used, at the intersection of two running rails, to provide support for wheels as passageways for their flanges, thus permitting wheels on either rail to lock the other.

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

gage line  A line 5/8 inch below the top of the center line of head of running rail along that side which is nearer the center of the track.

gauge (of track)  The distance between the gauge lines, measured at right angles thereto (standard gauge is 56-1/2").

gauge side  The side of the rail nearest the center of track.

grade  The ratio of rise and fall of the grade line to its length.

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

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

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

guard rail  A rail aid parallel with the running rails to prevent wheels from being derailed; or to hold wheel in correct alignment to prevent their flanges from striking the points of frogs or switches.

guard rail (track)  A rail or other structure laid parallel with the running rails of a track to control a derailed train, or at turnouts to hold wheels in correct alignment to prevent their flanges from striking the points of turnout or crossing frogs or the points of switches.

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 signal  (See SWITCH, HAND THROW)
<table>
<thead>
<tr>
<th>Term</th>
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</thead>
<tbody>
<tr>
<td>hazard</td>
<td>Any real or potential condition that can cause injury or death, or damage to or loss of equipment or property.</td>
</tr>
<tr>
<td>hazard level</td>
<td>A qualitative measure of hazards stated in relative terms.</td>
</tr>
<tr>
<td></td>
<td>Category I Negligible- Will not result in personal injury or system damage.</td>
</tr>
<tr>
<td></td>
<td>Category II Marginal Can be counteracted or controlled so that no injury to personnel or major system damage will be sustained.</td>
</tr>
<tr>
<td></td>
<td>Category III Critical</td>
</tr>
<tr>
<td></td>
<td>Category IV Catastrophic Will cause death to personnel.</td>
</tr>
<tr>
<td>heartwood face</td>
<td>The side of a timber tie about which the growth rings are concave.</td>
</tr>
<tr>
<td>heel of frog</td>
<td>The end of a frog farthest from the switch.</td>
</tr>
<tr>
<td>heel of switch</td>
<td>That end of a switch rail farther from the point and nearer the frog.</td>
</tr>
<tr>
<td>heel length</td>
<td>The distance between the half inch point of a frog and the heel, measured along the gauge line.</td>
</tr>
<tr>
<td>heel spread</td>
<td>The distance between gauge lines at the heel.</td>
</tr>
<tr>
<td>helical spring lock washer</td>
<td>A washer design with one or more coils within the general class of springs that accommodate compression loading (as compared to 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.</td>
</tr>
<tr>
<td>hi-rail</td>
<td>Attachments that make rubber tired vehicles (trucks, autos, special work equipment) capable of operating on rails.</td>
</tr>
<tr>
<td>high restraint fastener</td>
<td>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.</td>
</tr>
<tr>
<td>horizontal split head</td>
<td>A horizontal progressive defect originating inside of the rail head, usually 1/4” 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.</td>
</tr>
<tr>
<td>impedance, ballast</td>
<td>The impedance shunting of a track circuit due to the condition of the ballast.</td>
</tr>
</tbody>
</table>
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 guard rail  A longitudinal member, usually a metal rail, secured on top of the ties inside of the running rail to guide derailed car wheels.

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

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

insulated rail joint  (See JOINT, RAIL; INSULATED)

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 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 rails sits.

interlocked switch  (See SWITCH INTERLOCKED)

interlocking  An arrangement or signals and signal appliances, so interconnected that their movements must succeed each other in proper sequence.

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

joint  RAIL

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

junction  A location where train routes converge or diverge.

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

lead  The distance between the actual point of the switch and the half-inch point of the frog.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>lead curve</td>
<td>The curve in a turnout interposed between the switch and the frog.</td>
</tr>
<tr>
<td>line</td>
<td>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.</td>
</tr>
<tr>
<td>line end</td>
<td>The end of any tie from which all measurements are made.</td>
</tr>
<tr>
<td>lined side</td>
<td>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.</td>
</tr>
<tr>
<td>lining track</td>
<td>Shifting track laterally to conform to the established alignment.</td>
</tr>
<tr>
<td>locomotive</td>
<td>A prime mover for towing work cars or moving transit vehicles, generally in the 50 ton, and less than 100 horse-power class.</td>
</tr>
<tr>
<td>low restraint fastener</td>
<td>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 Restraine Systems.</td>
</tr>
<tr>
<td>lubrication</td>
<td>The application of lubricants, generally on a scheduled basis, to equipment and machinery.</td>
</tr>
<tr>
<td>machine</td>
<td>A device for power operation of switches, usually dual controlled for power or hand operations.</td>
</tr>
<tr>
<td>machine, interlocking</td>
<td>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.</td>
</tr>
<tr>
<td>main track</td>
<td>(See TRACK, MAIN)</td>
</tr>
<tr>
<td>maintenance</td>
<td>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.</td>
</tr>
<tr>
<td>maintenance of way shop</td>
<td>A transit facility expressly designed for maintenance of the plant and equipment within the jurisdiction of a Maintenance of Way Department.</td>
</tr>
<tr>
<td>maintenance of way department</td>
<td>That functional unit within a maintenance organization that generally has responsibility for track or guide way or structures. It sometimes includes responsibility for maintenance of all transit plant and equipment other than rolling stock.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>maintenance planning system</td>
<td>A system of cost, work and manpower planning, scheduling, and control, either manual or automated and generally part of a total management information system.</td>
</tr>
<tr>
<td>malfunction</td>
<td>Any anomaly wherein the system, subsystem or component fails to function as intended.</td>
</tr>
<tr>
<td>manganese steel insert</td>
<td>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.</td>
</tr>
<tr>
<td>monument</td>
<td>A permanent marker accurately defining a point from which the track work geometry may be plotted (i.e., elevation and center line of the track).</td>
</tr>
<tr>
<td>movable point</td>
<td>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.</td>
</tr>
<tr>
<td>number</td>
<td>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.</td>
</tr>
<tr>
<td>otm</td>
<td>Other track material: miscellaneous materials required to complete track construction, other than rail, special track work and ties.</td>
</tr>
<tr>
<td>out of face (referring to track work)</td>
<td>Work that proceeds completely and continuously over a given piece of track as distinguished from work at disconnected points only.</td>
</tr>
<tr>
<td>piped rail</td>
<td>One 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.</td>
</tr>
<tr>
<td>pit</td>
<td>A depressed area below floor level mainly between running rails or guide way for under-car lubrication, inspection and maintenance and equipped with all necessary utilities.</td>
</tr>
<tr>
<td>pitting</td>
<td>Localized corrosion.</td>
</tr>
<tr>
<td>plate, gauge</td>
<td>A steel plate installed on the switch tie at the switch points to secure the stock rails at the correct gauge.</td>
</tr>
<tr>
<td>plate, riser</td>
<td>A steel plate welded to a special switch plate for the purpose of raining the switch rail slightly above the stock rail.</td>
</tr>
<tr>
<td>plates, special</td>
<td>Plates for use in special track work, designed to replace the AREA standard gauge, switch, heel, and hook twin tie plates, commonly used under switches and frogs.</td>
</tr>
<tr>
<td>point, actual</td>
<td>That end of the switch rail farther from the frog, where the spread between the gauge lines of the switch rail and the stock rail is sufficient for a practicable switch point.</td>
</tr>
</tbody>
</table>
point detector  
(See DETECTOR, POINT)

point, half inch  
A point located at a distance from the theoretical point towards the heel equal in inches to one half the frog number, and at which the spread between gauge lines is one half inch. It is the origin from which measurements are usually made.

point, theoretical  
The point of intersection of the gauge lines of a frog.

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

points  
(See SWITCH POINT)

rail anchor  
1. Direct Fixation Fastener applications: A special track device that rigidly constrains the rail from longitudinal rail movement. The rail anchor is typically used in conjunction with low restrain or zero restraint fastener systems on elevated guide ways. The rail anchor serves as a control point for longitudinal rail movement and is placed strategically to transfer the least load to the support structure. The rail anchor bolts to the rail and to the concrete or steel support in a manner that allows no relative motion of the rail to the support structure at the rail anchor.

General railroad applications: A drive-on, single piece clip that develops high longitudinal rail restraint by com-locking mechanism between the clip, the rail and the rail support (usually a cross tie).

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

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 gauge.

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 flog 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 rail web for supplying D.C. 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 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. Atypically 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 with a nominal length of 39 feet or less, joined together by means of joint bars and bolts.

**rail rapid transit system**  An electrified fixed guide way transportation system, utilizing steel rails, usually operating on an exclusive grade-separated right-of-way for the mass movement of passengers within a city or 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 resistance**  Rail electrical resistance to ground. Rail resistance unit of measure is 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.

**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.
<table>
<thead>
<tr>
<th>Term</th>
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</thead>
<tbody>
<tr>
<td>rail section</td>
<td>The shape of the cross section of a rail at right angles to its length.</td>
</tr>
<tr>
<td>Rail, shop welded</td>
<td>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.</td>
</tr>
<tr>
<td>Rail, standard contact</td>
<td>An electrical conductor mode of a steel rail section mounted adjacent to the running rail for supplying D.C. traction power to the transit vehicles, sometimes referred to as the “third rail”.</td>
</tr>
<tr>
<td>Rail stop</td>
<td>A steel plate welded to a special plate to provide lateral restraint to the rail.</td>
</tr>
<tr>
<td>Railbound manganese steel</td>
<td>A frog consisting essentially of a single manganese steel body casting fitted into and between rolled rails and held together with bolts.</td>
</tr>
<tr>
<td>Resilient fastener</td>
<td>Direct Fixation Fasteners that use an elastomeric plate between the rail and the support.</td>
</tr>
<tr>
<td>Retaining wall section</td>
<td>A portion of track roadbed elevated or depressed from the surrounding area and located between retaining walls.</td>
</tr>
<tr>
<td>Right-of-way</td>
<td>Lands or rights used or held for operation.</td>
</tr>
<tr>
<td>Rigid clamp</td>
<td>Same as rigid rail clip.</td>
</tr>
<tr>
<td>Rigid rail clamp</td>
<td>Same as rigid rail clip.</td>
</tr>
<tr>
<td>Rigid rail clip</td>
<td>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.</td>
</tr>
<tr>
<td>Roadbed</td>
<td>The earth bed that support the ballast, ties and rail of a track structure.</td>
</tr>
<tr>
<td>Runoff</td>
<td>The term applied to that part of the precipitation which is carried off from the land upon which it falls. Also, the transition zone in lifting track, between track which has been raised and track which has not been raised.</td>
</tr>
<tr>
<td>Section, dead</td>
<td>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.</td>
</tr>
<tr>
<td>Semaphore</td>
<td>A signal in which day indications are given by the position of a movable arm.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Shatter cracks</td>
<td>Minute cracks in the interior of railheads, seldom closer than ½” 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.</td>
</tr>
<tr>
<td>Shim</td>
<td>A small piece of wood or metal placed between two members of a structure to bring them to a desired relative elevation.</td>
</tr>
<tr>
<td>Shoe</td>
<td>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 rail insulator and insulator.</td>
</tr>
<tr>
<td>Shoulder</td>
<td>That portion of the ballast between the end of the tie and the toe of the ballast slope.</td>
</tr>
<tr>
<td>Shunt</td>
<td>A by-path in an electrical circuit.</td>
</tr>
<tr>
<td>Siding</td>
<td>A track auxiliary to the main track for meeting, passing, or storing trains.</td>
</tr>
<tr>
<td>Single</td>
<td>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.</td>
</tr>
<tr>
<td>Sj plate</td>
<td>A plate for use under standard joints in direct fixation track.</td>
</tr>
<tr>
<td>Solid manganese steel</td>
<td>A frog consisting essentially of a single manganese steel casting.</td>
</tr>
<tr>
<td>Solid manganese steel</td>
<td>A crossing in which the frogs are of the solid manganese steel type.</td>
</tr>
<tr>
<td>Spiral (when used with respect to track)</td>
<td>A form of easement curve in which the change of radius is uniform throughout its length.</td>
</tr>
<tr>
<td>Split web</td>
<td>A longitudinal or diagonal transverse crack in the web of a rail.</td>
</tr>
<tr>
<td>Spot board</td>
<td>A sighting board placed above and across the track at the proposed height, to indicate the new surface and ensure its uniformity.</td>
</tr>
<tr>
<td>Spring</td>
<td>A switch in the operating mechanism of which is incorporated a spring devise 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.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Spring clamp</td>
<td>See elastic rail clip.</td>
</tr>
<tr>
<td>Spring rate</td>
<td>Equivalent to stiffness.</td>
</tr>
<tr>
<td>Spring switch</td>
<td>A track switch equipped with a spring mechanism arranged to restore points to normal position after having been trailed through.</td>
</tr>
<tr>
<td>Spring-rail, right hand and left hand</td>
<td>Starting at the toe end of a spring-rail frog and looking towards 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.</td>
</tr>
<tr>
<td>Stand</td>
<td>A device for manual operation of switches.</td>
</tr>
<tr>
<td>Standard times</td>
<td>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.</td>
</tr>
<tr>
<td>Station</td>
<td>A place designated for the purpose of loading and unloading passengers.</td>
</tr>
<tr>
<td>Station, above ground</td>
<td>A station in which the track and platform are either located on an aerial structure or rest directly on grade.</td>
</tr>
<tr>
<td>Station, underground</td>
<td>A station in which the major portion of the structure is located below the finished grade subway station.</td>
</tr>
<tr>
<td>Stinger</td>
<td>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, hi-rail vehicles.</td>
</tr>
<tr>
<td>Stock rail</td>
<td>A running rail against which the switch rail operates.</td>
</tr>
<tr>
<td>Stock rail</td>
<td>The rail against which the point of a switch, derail or movable point frog rests.</td>
</tr>
<tr>
<td>Sub ballast</td>
<td>A granular material, superior to most sub grade materials, which is spread on the finished sub grade before top ballast is applied, to provide drainage, prevent frost heaving and distributing load over the top of the sub grade.</td>
</tr>
<tr>
<td>Sub drain</td>
<td>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.</td>
</tr>
<tr>
<td>Sub grade</td>
<td>The finished roadbed surface upon which is laid the ballast and the track structure.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super elevation (of curves)</td>
<td>The vertical distance that the outer rail is above the inner rail.</td>
</tr>
<tr>
<td>Super-elevation</td>
<td></td>
</tr>
<tr>
<td>Switch</td>
<td>A track structure used to divert rolling stock from one track to another.</td>
</tr>
<tr>
<td>Switch and lock movement</td>
<td>A device, the operation of which performs the functions of unlocking, operating, and locking a switch, movable point frog, or derail.</td>
</tr>
<tr>
<td>Switch, electro pneumatic</td>
<td>A track switch operated by an electro-pneumatic switch and lock movement.</td>
</tr>
<tr>
<td>Switch, facing point</td>
<td>A track switch, the points of which face toward traffic approaching.</td>
</tr>
<tr>
<td>Switch, hand operated</td>
<td>A non-interlocked switch which can only be operated manually.</td>
</tr>
<tr>
<td>Switch, indicator</td>
<td>(See INDICATOR, SWITCH)</td>
</tr>
<tr>
<td>Switch, interlocked</td>
<td>A track switch within the interlocking limits, the control of which is interlocked with other function of the interlocking.</td>
</tr>
<tr>
<td>Switch, point</td>
<td>A movable tapered track rail, the point of which is designed to fit against the stock rail.</td>
</tr>
<tr>
<td>Switch position, normal</td>
<td>The position of a track switch and its controls when opposite to the defining track layout.</td>
</tr>
<tr>
<td>Switch position, reverse</td>
<td>The position of a track switch and its controls when opposite to the defining track layout.</td>
</tr>
<tr>
<td>Switch rod</td>
<td>A rod that connects two switch rails.</td>
</tr>
<tr>
<td>Switch, track</td>
<td>A pair of switch points with their fastenings and operating rods providing the means for establishing a route from one track to another.</td>
</tr>
<tr>
<td>Switch, trailing point</td>
<td>(See TRAILING SWITCH POINT)</td>
</tr>
<tr>
<td>tangent</td>
<td>Straight portion of railway alignment.</td>
</tr>
<tr>
<td>Test track</td>
<td>A length of track usually separated from a main line, or 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.</td>
</tr>
<tr>
<td>Third rail</td>
<td>A rail mounted on insulators alongside the running rail that provides traction power for train operation.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>third rail shoe</td>
<td>A truck-mounted power pickup device, which slides on, top of, on the side, or under, the third rail.</td>
</tr>
<tr>
<td>thread</td>
<td>The top surface of the head of a rail that contacts wheels.</td>
</tr>
<tr>
<td>threaded fastener system</td>
<td>See Bolted Fastener System.</td>
</tr>
<tr>
<td>throat</td>
<td>That portion of a yard that connects the storage areas to the mainline lead tracks or, in an automatic system, to the transfer zone.</td>
</tr>
<tr>
<td>throw</td>
<td>The distance through which the switch points are moved laterally, measured at the No. 1 switch rod.</td>
</tr>
<tr>
<td>tie, contact rail</td>
<td>The transverse member of the track structure that functions as a crosstie, but is longer and supports the contact rail.</td>
</tr>
<tr>
<td>tie, crosstie</td>
<td>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.</td>
</tr>
<tr>
<td>tie, switch</td>
<td>The transverse member of a track structure that functions as a crosstie, but is longer and supports a crossover or turnout.</td>
</tr>
<tr>
<td>toe</td>
<td>The end of a frog nearest the switch.</td>
</tr>
<tr>
<td>toe length</td>
<td>The distance between the half inch point of frog and the toe, measured along the gauge lines.</td>
</tr>
<tr>
<td>toe load</td>
<td>The clamping load generated by an elastic rail clip on a rail base.</td>
</tr>
<tr>
<td>toe spread</td>
<td>The distance between gauge lines at the toe.</td>
</tr>
<tr>
<td>tolerance</td>
<td>An allowable variation from dimensions or requirements specified.</td>
</tr>
<tr>
<td>track, ballasted</td>
<td>Track constructed of rail, ties, and ballast.</td>
</tr>
<tr>
<td>track, direct fixation (df)</td>
<td>Track constructed of rail and direct fixation rail fasteners attached by means of anchor bolts to a concrete surface.</td>
</tr>
<tr>
<td>track layout</td>
<td>An organized assemblage of track; the depiction thereof for control purposes.</td>
</tr>
<tr>
<td>track, main</td>
<td>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.</td>
</tr>
<tr>
<td>track, main line</td>
<td>A track designated by route name and direction for the purpose of carrying revenue passengers.</td>
</tr>
</tbody>
</table>
**track mobile**  A self-powered road-rail vehicle used for moving.

**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**  (See MOVEMENT, TRAILING)

**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.

**transit system safety**  (See SYSTEM SAFETY)

**transverse defect**  For defects found by detector cars, a tentative group classification, applied prior to he breaking of the rails, of all types of rail defect, which 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 frog, together with closure rails, by means of which rolling stock may be diverted from one track to another.

turnout
An arrangement of a switch and frog with closure rails by means of which trains may be diverted from one track to another.

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

un-bonded 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 “Ballast Pocket”.)

water table
The underground water level.

width
The distance between the gauge 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 guide way 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 time table 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 control tower
An airport-like structure overlooking as much of a yard and mainline as possible housing the personnel and equipment required to control movement of trains and work vehicles throughout the yard, transfer zones, and lead tracks.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>yard master</td>
<td>A Transportation Department employee, generally the supervisor or a yard’s transportation activity.</td>
</tr>
<tr>
<td>yard speed</td>
<td>(See SPEED, YARD)</td>
</tr>
<tr>
<td>zero longitudinal restrain systems (zlr)</td>
<td>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.</td>
</tr>
<tr>
<td>zero thermal stress temperature</td>
<td>The temperature at which a sting of continuous welded rail that has been restrained will not be stresses due to thermal expansion or contraction.</td>
</tr>
</tbody>
</table>
Annex B

Track surface table

A guideline for maximum allowable speeds based on individual track parameter deviations.

<table>
<thead>
<tr>
<th>CLASS OF TRACK</th>
<th>MAXIMUM ALLOWABLE SPEED</th>
<th>62' TWIST, SPIRALS</th>
<th>31' TWIST, SPIRALS</th>
<th>62' TWIST, CURVES AND TANGENT</th>
<th>31' TWIST, CURVES AND TANGENT</th>
<th>CROSSLEVEL</th>
<th>62' SURFACE</th>
<th>31' SURFACE</th>
<th>31' RUNOFF</th>
<th>MAXIMUM ALLOWABLE SPEED</th>
<th>CLASS OF TRACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>3&quot;</td>
<td>2&quot;</td>
<td>3&quot;</td>
<td>1 1/2&quot;</td>
<td>3&quot;</td>
<td>7/8&quot;</td>
<td>3 1/2&quot;</td>
<td>15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>2 3/4&quot;</td>
<td>1 7/8&quot;</td>
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<td>3/4&quot;</td>
<td>1 1/2&quot;</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
<td>1 1/4&quot;</td>
<td>1/4&quot;</td>
<td>1&quot;</td>
<td>90</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>
Annex C

(Informative)

Continuous welded rail recommended practices

C.1 Scope

This section provides recommended practices for rail transit systems that maintain CWR track. These recommended practices are not intended to supercede any rail transit systems existing practices or mandate that these recommendations shall be used. This is intended as a guide for Rail transit systems who do not have existing practices and is intended to be modified by individual rail transit systems for their specific needs, requirements and unique situations.

C.2 CWR theory

C.2.1 Continuous Welded Rail is defined herein as any rail 400 feet or more in length. This is not a mandated definition, a RTS can designate any length as CWR; some define CWR as any rail greater than a standard 78’ length. Rail transit systems should clearly define what they consider as CWR.

C.2.2 Thermal expansion

C.2.2.1 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 will attempt to shorten. If rail is free to change length, with changes in rail temperature, it will behave in a predictable manner.

C.2.2.2 Formula for expansion of unrestrained rail

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

\[ R_L \times 12 \times \Delta T \times 0.0000067 = \Delta R_L; \]

where:

- \( R_L \) = Rail Length (in feet)
- 12 = Conversion of rail length from feet to inches
- \( \Delta T \) = Change in Rail Temperature (in Fahrenheit degrees). The change in rail temperature from when it was originally measured.
- 0.0000067 = Coefficient of Expansion for rail
- \( \Delta R_L \) = Change in rail length (in inches).

The effect that temperature has on unrestrained rail length is shown in Table C1.
### Table C1 – Longitudinal rail expansion vs. temperature change

<table>
<thead>
<tr>
<th>∆T Change in rail temperature</th>
<th>Rail length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100’ (0.02 MILE)</td>
</tr>
<tr>
<td>10°F</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>20°F</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>30°F</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>40°F</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>50°F</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>60°F</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>70°F</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>80°F</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>90°F</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>100°F</td>
<td>3/4&quot;</td>
</tr>
</tbody>
</table>

### C.2.2.3 Rail Size and Amount of Rail Movement

The size or weight of the rail has nothing to do with the amount the rail will expand or contract. Only the 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 pound or 136 pound rail sections.

### C.2.2.4 Longitudinal Rail Stresses

#### C.2.2.4.1 Longitudinal Rail Stresses from Temperature Changes

The problem with CWR is that it attempts to change rail length with changes in temperature. Rail is installed such that this expansion and contraction cannot occur, hence huge stresses can build up along the rail, and these forces are called longitudinal forces.

There are three 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. When the rail temperature is equal to that where no expansion or contraction can occur, the rail is “neutral”. Since rail has only one temperature that it is neutral, odds are that some longitudinal forces exist.
Where size or weight does not affect the amount that rail expands or contracts, it does affect the forces generated. The larger the rails size the greater the force generated with a temperature change. The forces can be calculated using the following formula:

\[ R_W \times \Delta T \times 19.606 = \Delta L_F; \]  
where:

- \( R_W \) = Rail Weight (in pounds per yard)
- \( \Delta T \) = Change in Rail Temperature (in Fahrenheit degrees).
- \( \Delta L_F \) = Longitudinal Force (in pounds).
- 19.606 = Constant, derived from Young’s Modulus \((29.85 \times 10^6 \text{ pounds/square inches})\)
  \times Coefficient Expansion of Steel \((6.7 \times 10^{-6})\)
  \times Ratio of Rail Cross Section and Weight per Yard \((0.098)\).

The effect that rail size has on these longitudinal rail forces is shown in Table C1.

| Table C2 – Longitudinal Rail Forces vs. Temperature Change (in pounds) |
|-----------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| \( \Delta T \) 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 | 29,409 | 44,114 | 49,015 | 56,367 | 66,660 |
| 50°F | 58,818 | 88,227 | 98,030 | 112,735 | 133,321 |
| 75°F | 88,227 | 132,341 | 147,045 | 169,102 | 199,981 |
| 100°F | 117,636 | 176,454 | 196,060 | 225,469 | 266,642 |

C.2.2.4.2 Longitudinal Rail Stresses from Trains

In addition to the longitudinal stresses induced by changes in rail temperature, trains can generate huge 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 rail transit systems the effects of these forces can be compounded since trains stops and starts occur 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 systems (ATC) further exasperate these effects, since it 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 in different locations and rates. While the adverse affects of, for example, a station stop, will still be present with or without an ATC system, the ATC system will be more prominent.
C.3 Longitudinal rail restraint

Section C.2 discusses the large forces that can be generated in CWR. When CWR is in the track these forces are offset with four restraints: tie plate/rail seat friction, joint bar restraint, fastening system and ballast.

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

At properly maintained rail joints the longitudinal restrain of the rail is approximately equal to the clamping force of each bolt. A properly torqued bolt provides about 25,000 pounds of restraining force. For a rail joint with 4 bolts installed, this equates to 100,000 pounds of restraining force; 150,000 pounds for 6-hole joint bars. The key point is a “properly maintained” rail joint. Loose rail joints do not provide as much restrain 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 restrain are combined, such that no rail anchors are required. The longitudinal restrain capacity of a well maintained fastening system is approximately 5,000 pounds per tie, more with resilient fastening systems.

Direct Fixation (DF) fastening systems, also known as Slab Track or continuously supported track, can provide significantly high restraining forces. This is also true of street running track where the rail is somewhat shielded from the sun’s energy, in addition to 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, the results are 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 maintain fastening system provide approximately 1,300 pounds per anchored tie. This can be significantly reduced if there is insufficient ballast, the ballast is not well consolidated, 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 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 to be transferred 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 any rail movement does not adversely affect the operation of the bridge.
C.4 Determining rail temperatures

Each RTS needs to designate the temperature ranges for installing and maintaining CWR rail. These designations need to be made for each geographic region. Even on fairly short rail transit systems, the tracks can pass through numerous microclimates; separate calculations should be made for each region where CWR is used. Even if the climate is fairly uniform throughout a rail transit systems property, consideration should be given to different track forms, such as at-grade, elevated (aerial) and subways; the rail temperatures can vary in 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 then 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 should be used for each of these geographic areas in which the CWR is located. The experience and knowledge of “local” personnel should be relied upon in making these geographical determinations.

Some rail transit systems choose not to thermally adjust rail in subway areas. Since the temperature in tunnels and subways is typically constant and not subject to extreme and sudden changes in temperature, this can be safely done. However, consideration should be given to controlling the rail installation temperature during construction, at portal areas, stations and ventilation ducts. While the temperature in subways may be “on average” constant these special areas may be subjected to sudden temperature swings.

CWR should be laid when the rail temperature is within the temperature range specified by the following equations. See Table C5.

\[
\begin{align*}
DRT_{\text{MIN}} &= \frac{(2Ht + Lt)}{3} + 10; \text{ and,} \\
DRT_{\text{MAX}} &= \frac{(2Ht + Lt)}{3} + 25 \pm 5; \text{ where,} \\
DRT_{\text{MIN}} &= \text{Minimum Desired Rail Temperature} \\
DRT_{\text{MAX}} &= \text{Maximum Desired Rail Temperature} \\
Ht &= \text{Highest Rail Temperature} \\
Lt &= \text{Lowest Rail Temperature}
\end{align*}
\]

Rail temperature is not directly related to ambient or air temperature. At night, or when there are heavy clouds, the rail temperate closely follows the ambient temperature. However, the rail temperature will lag behind the ambient, since it takes time for the rail temperature to change; the faster that 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 the direct sunlight its temperature can significantly increase over the ambient. It is not unusual for the rail temperature to be as much as 40 Fahrenheit degrees higher than ambient or more 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 there is a plus or minus 5 degrees included in the formula. Which end of the range that is appropriate for each RTS should be determined by experience. If a RTS experiences a extremely low rail temperatures in winter and high temperatures in summer it may be appropriate to use the minus 5 degrees, where if the temperatures are more temperate or high temperature spikes are common, then the plus 5 may be appropriate. Again, the experience of 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 be sometimes obtained on the Internet. Another excellent source are government weather agencies. If research time is unavailable, 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 a RTS. 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, a sun kink is far more dangerous than a rail pull-apart. A pull-apart will typically be show up as a false occupancy in the signal circuit, 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 RTS 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 only be a few degrees; not so large as to allow sloppy workmanship.

When making the PRLT determination, it is advisable for rail transit systems 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.

### C.5 Maintenance activities on CWR track

#### C.5.1 Rail transit systems should develop specific direction for track construction and maintenance personnel describing what actions should be taken when disturbing track with CWR. These policies should include what specific actions are required for temperature ranges above and below the PRLT. These policies should include what speed restrictions are required and what precautions should be taken, and what can be done to minimize or eliminate the need for speed restrictions. Rail transit systems should in no way limit their ability to efficiently and productively perform maintenance and construction activities with existing resources. However, the developed policy should provide enough direction to guide personnel in what changes they can make to their existing work methods to ensure the work is safely performed and will remain safe for traffic after the work is completed.

#### C.5.2 If the track is disturbed when the rail temperature is above or below the NRT, 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 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 example of work that would constitute disturbing CWR track: track undercutting; 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 adding additional activities that are commonly performed by a specific RTS or activities that are unique to a specific RTS with unique types of track. It is not mandated that each of these specific activities should have a special detailed policy or procedure. These types of activities should be considered when developing a policies or procedures. Whenever possible generic policies and procedures should be developed.

C.5.3 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:

1. Out-of-face track raising and lining,
2. Rail renewal,
3. Tie renewals (with or without raising), or
4. Disturbing the ballast section.

C.6 Surfacing and aligning CWR track

C.6.1 General

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

C.6.2 Affect of repairing surface and alignment on neutral temperature

Surfacing and aligning CWR track can greatly affect the neutral temperature of the rail. Where the surface of the track is in extremely poor condition, then resurfacing will reduce the neutral temperature of the rail. On rough track, 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.

C.6.3 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, the track will tend to move inward, usually not uniformly, creating misalignment “flat spot” in the curve. Where the neutral temperature is to 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 temperate. This illustrated in Table C3, which shows the changes for selected curve radii for curves that are 100’ long.
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.

C.7 CWR Special inspection

C.7.1 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. Greater stress is usually placed upon hot weather special inspections, but cold weather inspections should also be considered. Some rail transit systems do not perform specific cold weather inspection, but rather rely upon signal circuits to provide broken rail and pull-apart detection. It should be taken in consideration is that signal circuits do not provide 100% reliability for pull-apart detection. Rail joints, special trackwork, restraining rails, turnouts and crossings can provide an alternate path for the signal circuits, negating detection of a pull-apart on the running rails.

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 should be identified in advance of failure or weather extremes so repairs can be made on a programmed basis.

C.7.2 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 at rail transit systems is the restrictions 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 they have 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(s). This allows persons performing inspections to see if changes have occurred or problems have developed since the last pass.

During temperature extremes a good resource for information concerning what adverse effects of the temperature extremes are train operation control centers. 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 is an excellent indicator 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.

C.7.3 When special inspections should be performed

Rail transit systems should specify when special inspections should be performed on CWR. The “trigger level” can be as simple as when the ambient temperature is above or below certain temperature. Another method is to perform special inspections when the temperature is above or below the PRLT by a certain amount. Others perform special CWR inspections when there is a sudden change in temperature within a certain time period. Some rail transit systems only perform special inspections on CWR track as determined by inspectors or management staff.

Any of these, a combination of these, or other methods can be used for determining a trigger level for when special inspections are made. Rail transit systems should have specific guidelines in place to guide those persons who perform and or manage the special inspections. The methods and determinations should be based primarily on the knowledge and experience of the RTS. The key is to ensure that sufficient thought has gone into the decision making process so guidelines are developed to cover possible scenarios and maintain safe, reliable and economical train operations.
Along with the guidelines for when and how special inspections should be made, rail transit systems should include what inspection reports or other documentation, if any is required when special inspections are made.

**C.7.4 Items to watch for during special inspections of CWR**

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

**C.7.4.1 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

**C.7.4.2 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 closed)

**C.7.4.3 Rail Fasteners**

- Tearing, lifting or separating of direct fixations 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
C.7.4.4 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

C.7.4.5 Track Geometry

- Misalignment, kinks, buckles in the track, in particular at fixed objects such as road crossings, bridge or subway approaches and special trackwork
- Changes in alignment with temperature changes
- Irregular gage
- Pumping track (excessive up and down movement under load)

C.7.4.6 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

C.7.4.7 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
C.8 Slow orders/speed restriction on CWR track

C.8.1 While CWR track may be stable and able to withstand the thermal expansion and contraction forces the dynamic loads imposed on the track by trains can reduce the tracks ability to maintain alignment. Train braking, increases in rail temperature from the friction of the train wheels, and the up/down movement of the track that occurs as trains pass all work to degrade the tracks ability to maintain stability. Some dynamic loadings that can affect CWR tracks ability to remain stable are:

- Train Speed
- Axle loads, the heavier the axle loads the worse the effects
- Train length, longer trains disturb the track more with a cumulative affect; typically the longer the train the greater the track displacement. Also the temperature increase from rolling friction is greater
- Train frequency
- Sharp Curves, the sharper the horizontal curvature, the greater the translation of longitudinal rail forces to lateral track forces
- Steep Grades, the steeper the grade the greater the affect 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 affects 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.

C.8.2 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 rail transit systems. Experience and knowledge of the individual property and types of operations should weigh heavily in the decision making process. Many look to the polices and procedures of heavy haul freight railroads for examples of what should be done. It should be kept in mind that these polices 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 used, the RTS should weigh all of 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; and,
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. It may be that for a particular RTS that no special speed restriction are required, however whatever the policies and procedures are, they should be clearly identified.

It may be appropriate to have speed restrictions on one type of track but not another, or in one area but not another. For example, a RTS may determine that temperature and/or maintenance related speed restriction are not needed in subways or DF track, but are on ballasted track. Another scenario is where a RTS may require speed restrictions on older ballasted wood tie track, but not on newer ballasted track. Again, the recommendations provided here are not intended to compel a RTS to certain practices, only recommend that certain scenarios be included in the decision making process.

C.8.3 If it is determined that speed restriction are required, in circumstances, what the speeds shall be is another factor in the decision making factor. Again many look to the policies and practices of heavy haul freight railroads or those of other rail transit systems. But, each RTS is unique. Many operate using Automated Train Control (ATC) systems and these systems may only provide for certain speed restrictions to be placed. For example, it does no good to adopt a policy requiring a 25-mile an hour speed restriction, if only 15 and 30 mile per hour speed restrictions are possible. Existing Operational rules, realistically possible operational rules changes and ATC system design should weigh heavily upon what speeds are used when placing speed restrictions. 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.

C.9 Rail temperature measurement

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

If mechanical or liquid type rail thermometers are used, at least two thermometers should be used simultaneously; the average of the temperatures shown on the thermometers should be used for making the 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 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.
C.10 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. Some rail transit systems may require special electrical safety procedures if this tool is used on the running rail on the same side as the third rail.

- Rail Heaters – This method uses equipment that rides along the rail that heats the rail using an exposed flame or infrared heating units. Propane has historically been used for rail heater, however units are available that use diesel fuel, which can be more desirable in some cases due to easier re-supply and a lower fire hazard. If not properly used, this method can cause damage to 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 sufficient precautions are taken. It should be noted that because of the possible fire risk, some rail transit systems are not allowed to take propane or large amounts of flammable gasses 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 then lit. The resultant heat from the wicking off of the fuel then heats the rail. Before these are used, it would be wise to discuss their use with fire protection agencies that having jurisdiction. Many times when these are used, concerned citizens will call out 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 smokeless chemical process that does not have an open flame.

- Natural Air Temperature – This method relies upon the effects of the air temperature on the rail to heat or cool the rail. This method can be somewhat inconvenient, since work shall be scheduled depending on the weather. When work shall be performed when the rail temperatures too low, such as repair of a pull-apart or a rail renewal, the rail shall be readjusted at a later date. Great care shall be taken so the location(s) that require readjusted are promptly readjusted. The risk is that a hot weather spell occurs before the location(s) are readjusted. Good record keeping and communication is the key to preventing impacts to train operations. The eventuality that speed restrictions and/or track outages may be necessary when early heat spells should be expected. 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, this in addition to the additional resources required for readjustment.

- Water Spray – This method is used exclusively for cooling the rail down, 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 to cool it. Using refrigerated or ice water can speed up this process.
C.11 Practical CWR maintenance applications

The following are some recommended methods for dealing with specific common CWR maintenance tasks. Again, these are recommendation, not mandated procedures. These are provided only as examples to guide rail transit systems. It is acceptable for rail transit systems to use other methods to perform CWR maintenance tasks. What is important, is rail transit systems provide adequate direction and understanding to maintenance personnel as to what is required to leave the track fit after work is performed.

Rail transit systems 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 in these situations. Method(s) should be developed and used by the rail transit systems that require them. Rail transit systems should include these methods and practices in their procedures.

C.11.1 Rail adjustment distant

A determination to be made by a RTS is how much distance shall be thermally adjusted along the rail, when it is disturbed. Some rail transit systems use as little as 200 feet in each direction, other use as high as 500 feet. Whatever the distance a RTS uses, it should be clearly defined. This distance policy should include some direction concerning what it determines as fixed objects are. Items such as frogs, crossing diamonds, etc. can be used as an end to rail adjustment. For example if the rail is cut 100’ from a frog (along the same rail) it may not be necessary to adjust the rail 200’ back on that end, just up to the frog. Again, the rail transit systems practice should be clearly defined. To reduce confusion 200’ is used in the following recommended procedures. This distance may not be appropriate for a particular RTS. Each RTS should assess the required distance and make their own determination.

C.11.2 New Construction of CWR Track

C.11.2.1 Prior to performing any thermal rail adjustment, all surface and alignment should be completed.

C.11.2.2 Remove rail clips and/or rail anchors. On cut spike track the rail should slide through the plates.

C.11.2.3 Create adjustment stations by creating match marks on the rail, at least every 200’, 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.

C.11.2.4 Measure the rail temperature.

C.11.2.5 Determine the difference between the current rail temperature and Preferred Rail Laying Temperature (PRLT).

C.11.2.6 Using temperature difference, determine the amount of rail movement required at each adjustment station. The movement should be accumulative; for example if 1/2’’ movement is required at the first station, then 1’’ will be required at the second, 1 1/2’’ at the next and so on.
Do not use the same rail movement calculated for 200’ repeatedly, rather use the amount individually calculated for 200’, 400’, 600’, etc. This will eliminate any accumulative errors created by the rounding. This is particularly important when long strings of CWR are adjusted.

C.11.2.7 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.

C.11.2.8 Continue until the desired rail movement has occurred at all of the adjustment stations.

C.11.2.9 At the end point of previous track construction or at tie-in locations on existing track, the existing track should be re-adjusted at least 200’ back. Ends of track tend to pull back, in the same way, as it is easier to pull a chain rather than push it. This lowers the neutral rail temperature.

C.11.2.10 Notes

C.11.2.10.1 The temperature of the rail should be constantly monitored throughout the adjustment process. If the rail temperature changes, the amount of rail movement at subsequent stations should be recalculated.

C.11.2.10.2 During rail adjustment, the rail should be vibrated to aid rail movement through the rail seats. DO NOT HIT THE RAIL WITH HAMMERS, this will damage the rail. If a rail vibrator is not available, 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.

C.11.2.10.3 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”. 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.

C.11.2.10.4 If the track has to be repaired after the rail adjustment is completed, and then the CWR should be readjusted. For example if CWR Track has to resurface 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 a 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 broken rail.

C.11.2.10.5 Both rails should be simultaneously adjusted. When one rail is to be adjusted at a time, then the adjustment of one rail should not proceed too far ahead of the other. This will prevent any undo stress on the ties and fasteners and prevent slewing of the ties.

C.11.3 Installing CWR in Existing Track

C.11.3.1 Prior to cutting the existing rail place match 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.

**C.11.3.2** 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’ back.

**C.11.3.3** After the new rail is placed and gaged, measure the rail temperature.

**C.11.3.4** Measure the rail temperature.

**C.11.3.5** Determine the difference between the current rail temperature and Preferred Rail Laying Temperature (PRLT).

**C.11.3.6** Using temperature difference, determine the amount of rail movement required at each adjustment station. The movement should be accumulative; for example if ½” movement is required at the first station, then 1” will be required at the second, 1 1/2” at the next and so on. Do not use the same amount of rail movement calculated for 200’ repeatedly, rather use the amount individually calculated for 200’, 400’, 600’, etc. This will eliminate any accumulative errors created by the rounding. This is particularly important when long stretches of CWR are adjusted.

**C.11.3.7** 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.

**C.11.3.8** Continue until the desired rail movement has occurred at all of the adjustment stations.

**C.11.3.9 Notes**

**C.11.3.9.1** The temperature of the rail should be constantly monitored throughout the adjustment process. If the rail temperature changes, the amount of rail movement at subsequent stations should be recalculated.

**C.11.3.9.2** During rail adjustment, the rail should be vibrated to aid rail movement through the rail seats. **DO NOT HIT THE RAIL WITH HAMMERS**, this will damage the rail. If a rail vibrator is not available, 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.

**C.11.3.9.3** 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”. 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.
C.11.3.9.4 Where both rails are replaced at the same time, then both should be simultaneously adjusted. When one rail is to be adjusted at a time, then the adjustment of one rail should not proceed too far ahead of the other. This will prevent any undo stress on the ties and fasteners and prevent slewing of the ties.

C.11.4 Repair of broken rails and pull-aparts in CWR track

C.11.4.1 If the rail temperature is hot, or is expected to rise during the repair process, the rail ends should be by-passed to ensure the rail ends will not jamb.

C.11.4.2 Remove the rail anchors and or fasteners for 200’ 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.11.4.3 Vibrate the rail to ensure it is at its natural length.

C.11.4.4 Measure the rail temperature.

C.11.4.5 Determine the difference between the current rail temperature and Preferred Rail Laying Temperature (PRLT).

C.11.4.6 Using the temperature difference, determine the amount of rail movement required for 400’. If the gap is more than the required rail movement, then additional rail is required and a rail will need to be cut in.

C.11.4.7 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, 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, provide the additional gap required for the field weld. Where the rail temperature is more than the PRLT, then the gap required for field weld should be subtracted from the overlap.

C.11.4.8 Thermally adjust the rail until the rail ends match.

C.11.4.9 Join the rail, using rail joint(s) or field welding as required.

C.11.4.10 Notes

C.11.4.10.1 During rail adjustment, the rail should be vibrated to aid rail movement through the rail seats. DO NOT HIT THE RAIL WITH HAMMERS, this will damage the rail. If a rail vibrator is not available, 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.

C.11.4.10.2 Rail transit systems should determine the minimum length of rail that can be used for making repairs. This minimum rail length should be reiterated in the rail transit systems rail adjustment procedure, where instructions are given to install rail.

C.11.4.10.3 Some rail transit systems only drill 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 rail transit systems rail adjustment procedure, where instructions are given to create rail joints in CWR track.

C.11.5 Repair of Sun-Kinks or suspected improperly adjusted rail in CWR Track

C.11.5.1 Carefully cut the rail(s). If the rail is to be cut with a rail saw, 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 harms way.

C.11.5.2 Remove the rail anchors and or fasteners for at least 200’ 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.11.5.3 Vibrate the rail to ensure it is at its natural length.

C.11.5.4 Measure the rail temperature.

C.11.5.5 Determine the difference between the current rail temperature and Preferred Rail Laying Temperature (PRLT).

C.11.5.6 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.

C.11.5.7 Thermally adjust the rail until the rail ends match.

C.11.5.8 Join the rail, using rail joint(s) or field welding as required.

C.11.5.9 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.

C.11.5.10 Notes

C.11.5.10.1 Typically, both rails should be adjusted at a location of a sun-kink. Unless there is specific information, such as 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, both rails should be adjusted.

C.11.5.10.2 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, if not adjusted it should be carefully watched. Where surface and alignment has recently been performed on a curve, then they track may have been aligned inward reducing the adjustment of the rail, of 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 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 that that required by the RTS.

C.11.5.10.3 If the rail is to be cut with a torch, first cut away approximately 3” of the rail head,
then cut away approximately 3” 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 harms way while the cut is being made. Many rail transit systems have policies concerning
torch cut rails. Some rail transit systems 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”
to eliminate shatter cracks caused by the torch cutting and the potential of rail breaks. Some rail
transit systems allow torch cut rail ends to be field welded if the weld is made within an hour
from when the cut was made. Whatever the policies of the RTS, they should be reiterated in the
rail transit systems rail adjustment procedure, where instructions are given to cut rail in CWR
track.

C.11.5.10.4 During rail adjustment, the rail should be vibrated to aid rail movement through the
rail seats. DO NOT HIT THE RAIL WITH HAMMERS, this will damage the rail. If a rail
vibrator is not available, 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.

C.11.5.10.5 Rail transit systems should determine the minimum length of rail that can be used
for making repairs. This minimum rail length should be reiterated in the rail transit systems rail
adjustment procedure, where instructions are given to install rail.

C.11.5.10.6 Some rail transit systems only drill 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 rail transit systems rail adjustment procedure, where instructions are
given to create rail joints in CWR track.

C.11.6 Cutting in a rail or rail joint in CWR track

C.11.6.1 Cut the rail at the desired location, taking the necessary precautions (see notes below).

C.11.6.2 Remove the rail anchors and or fasteners for least 200’ 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.11.6.3 Vibrate the rail to ensure it is at its natural length.

C.11.6.4 Measure the rail temperature.

C.11.6.5 Determine the difference between the current rail temperature and Preferred Rail
Laying Temperature (PRLT).

C.11.6.6 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.

C.11.6.7 Thermally adjust the rail until the rail ends match.

C.11.6.8 Join the rail, using rail joint(s) or field welding as required.

C.11.6.9 Notes

C.11.6.9.1 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, the stress can be relieved by remove 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 harms way.

C.11.6.9.2 If the rail is cut with a torch and it is under compression, first cut away approximately 3” of the rail head, then cut away approximately 3” 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 harms way while the cut is being made. Many rail transit systems have policies concerning torch cut rails. Some rail transit systems 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” to eliminate shatter cracks caused by the torch cutting and the potential of rail breaks. Some rail transit systems allow torch cut rail ends to be field welded if the weld is made within an hour from when the cut was made. Whatever the policies of the RTS, they should be reiterated in the rail transit systems rail adjustment procedure, where instructions are given to cut rail in CWR track.

C.11.6.9.3 If the rail temperature is extremely 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.

C.11.6.9.4 During rail adjustment, the rail should be vibrated to aid rail movement through the rail seats. DO NOT HIT THE RAIL WITH HAMMERS, this will damage the rail. If a rail vibrator is not available, 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.

C.11.6.9.5 If the CWR is to be field welded, gaps should be left for the field weld. The OEM of the field weld kits should determine the gap, typically 1”. 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.

C.11.6.9.6 Rail transit systems should determine the minimum length of rail that can be used for
making repairs. This minimum rail length should be reiterated in the rail transit systems rail adjustment procedure, where instructions are given to install rail.

C.11.6.9.7 Some rail transit systems only drill 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 rail transit systems rail adjustment procedure, where instructions are given to create rail joints in CWR track.

C.12 Communication & record keeping

Good communication between 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 whom normally maintain and inspect the track know and understand what was done to repair the CWR track. Questions that need to be answered are: Where was the repair made? Was the rail readjusted? If so, to what temperature? Which rail?, etc. One of the key elements to maintaining a given stretch of track is knowing exactly where and what has been done to it. Even in smaller organizations, communicating and record keeping is 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 contract 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 shall 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 rail transit systems 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 rail transit systems to ensure that crews return as soon as possible to properly re-adjust the rail. If these records are not maintained, the usual effect is latter impacts to the operations of trains.
An example of a CWR disturbance report is shown in Figure C1.

<table>
<thead>
<tr>
<th>Division or Line:</th>
<th>Track:</th>
<th>Mile Post or Engineering Station:</th>
<th>Date CWR was Disturbed:</th>
</tr>
</thead>
</table>

Rail: □ North □ South □ East □ West

Weather:

Type of work: □ Rail Replacement □ Pull-Apart □ Broken Rail □ Sun-Kink

Other (explain):

Amount of rail added or removed:

Distance rail was adjusted or moved:

Was Rail Cut? □ Yes □ No

Was Rail Properly Adjusted: □ Yes □ No

Temperature Rail was Adjusted to:

Reason rail was not properly adjusted:

Name of Person Completing Report: Date Report Completed:

C.13 Benefits of CWR

To some it may appear that the use of CWR may not worth the extra effort. This is not the case. CWR eliminates the need for rail end welding, battered rail joints, cracked angle bars, broken joint bolts, re-tourquing rail joints, surfacing and gaging at rail joints, 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 this, surfacing and aligning cycles are greatly lengthened. Another benefit is a reduction in noise from passing trains.

C.14 References

There is a large amount of published material available concerning the maintenance of CWR. Much research has been performed and more is currently underway. Different predictive models and various versions of computer software are available for predicting the affects of temperature changes on CWR track. An excellent resource is the American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering. In particular reference Volume 1, Chapter 5.

C.15 Thermal rail adjustment table

Table C4 details the changes in rail length for given rail lengths and temperature changes, using the formula: \( RL \times 12 \times \Delta T \times 0.0000067 = \Delta RL \); where: \( RL = \) Rail Length (in feet); \( \Delta T = \) Change in Rail Temperature (in Fahrenheit degrees) and \( \Delta RL = \) Change in rail length (in inches).
<table>
<thead>
<tr>
<th>Rail Length</th>
<th>∆R&lt;sub&gt;L&lt;/sub&gt;</th>
<th>∆T = Change in Rail Temperature</th>
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<td>2000'</td>
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### Table C4 (continued) – $\Delta R_{L}$ Change in rail length

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<td>60°F</td>
<td>4 5/16&quot;</td>
<td>4 13/16&quot;</td>
<td>5 5/16&quot;</td>
<td>5 13/16&quot;</td>
<td>6 1/4&quot;</td>
<td>6 3/4&quot;</td>
<td>6 15/16&quot;</td>
<td>7 1/4&quot;</td>
</tr>
<tr>
<td>65°F</td>
<td>4 11/16&quot;</td>
<td>5 1/4&quot;</td>
<td>5 3/4&quot;</td>
<td>6 1/4&quot;</td>
<td>6 13/16&quot;</td>
<td>7 5/16&quot;</td>
<td>7 1/2&quot;</td>
<td>7 13/16&quot;</td>
</tr>
<tr>
<td>70°F</td>
<td>5 1/16&quot;</td>
<td>5 5/8&quot;</td>
<td>6 3/16&quot;</td>
<td>6 3/4&quot;</td>
<td>7 5/16&quot;</td>
<td>7 7/8&quot;</td>
<td>8 1/8&quot;</td>
<td>8 7/16&quot;</td>
</tr>
<tr>
<td>75°F</td>
<td>5 7/16&quot;</td>
<td>6&quot;</td>
<td>6 5/8&quot;</td>
<td>7 1/4&quot;</td>
<td>7 13/16&quot;</td>
<td>8 7/16&quot;</td>
<td>8 11/16&quot;</td>
<td>9 1/16&quot;</td>
</tr>
<tr>
<td>80°F</td>
<td>5 13/16&quot;</td>
<td>6 7/16&quot;</td>
<td>7 1/16&quot;</td>
<td>7 11/16&quot;</td>
<td>8 3/8&quot;</td>
<td>9&quot;</td>
<td>9 1/4&quot;</td>
<td>9 5/8&quot;</td>
</tr>
<tr>
<td>85°F</td>
<td>6 1/8&quot;</td>
<td>6 13/16&quot;</td>
<td>7 1/2&quot;</td>
<td>8 3/16&quot;</td>
<td>8 7/8&quot;</td>
<td>9 9/16&quot;</td>
<td>9 13/16&quot;</td>
<td>10 1/4&quot;</td>
</tr>
<tr>
<td>90°F</td>
<td>6 1/2&quot;</td>
<td>7 1/4&quot;</td>
<td>7 15/16&quot;</td>
<td>8 11/16&quot;</td>
<td>9 7/16&quot;</td>
<td>10 1/8&quot;</td>
<td>10 7/16&quot;</td>
<td>10 7/8&quot;</td>
</tr>
<tr>
<td>95°F</td>
<td>6 7/8&quot;</td>
<td>7 5/8&quot;</td>
<td>8 3/8&quot;</td>
<td>9 3/16&quot;</td>
<td>9 15/16&quot;</td>
<td>10 11/16&quot;</td>
<td>11&quot;</td>
<td>11 7/16&quot;</td>
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<tr>
<td>100°F</td>
<td>7 1/4&quot;</td>
<td>8 1/16&quot;</td>
<td>8 7/8&quot;</td>
<td>9 5/8&quot;</td>
<td>10 7/16&quot;</td>
<td>11 1/4&quot;</td>
<td>11 9/16&quot;</td>
<td>12 1/16&quot;</td>
</tr>
</tbody>
</table>

$\Delta T =$ Change in Rail Temperature

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C.16 Desired rail laying temperature range table

Table C5 provides desired rail laying temperature ranges for selected high and low rail temperatures. The Preferred Rail Laying Temperature (PRLT) used by a RTS should within the ranges shown in Table C5, given the high and low rail temperatures that the RTS experiences. For more information, see C1.4.

<table>
<thead>
<tr>
<th>Lowest Rail Temperature (Lt)</th>
<th>Highest Rail Temperature (Ht)</th>
<th>80°F</th>
<th>90°F</th>
<th>100°F</th>
<th>110°F</th>
<th>120°F</th>
<th>130°F</th>
<th>140°F</th>
<th>150°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40°F</td>
<td></td>
<td>50.0°F to 65.0°F</td>
<td>56.7°F to 71.7°F</td>
<td>63.3°F to 78.3°F</td>
<td>70.0°F to 85.0°F</td>
<td>76.7°F to 91.7°F</td>
<td>83.3°F to 98.3°F</td>
<td>90.0°F to 105.0°F</td>
<td>96.7°F to 111.7°F</td>
</tr>
<tr>
<td>-35°F</td>
<td></td>
<td>51.7°F to 66.7°F</td>
<td>58.3°F to 73.3°F</td>
<td>65.0°F to 80.0°F</td>
<td>71.7°F to 86.7°F</td>
<td>78.3°F to 93.3°F</td>
<td>85.0°F to 100.0°F</td>
<td>91.7°F to 106.7°F</td>
<td>98.3°F to 113.3°F</td>
</tr>
<tr>
<td>-30°F</td>
<td></td>
<td>53.3°F to 68.3°F</td>
<td>60.0°F to 75.0°F</td>
<td>66.7°F to 81.7°F</td>
<td>73.3°F to 88.3°F</td>
<td>80.0°F to 95.0°F</td>
<td>86.7°F to 101.7°F</td>
<td>93.3°F to 108.3°F</td>
<td>100.0°F to 115.0°F</td>
</tr>
<tr>
<td>-25°F</td>
<td></td>
<td>55.0°F to 70.0°F</td>
<td>61.7°F to 76.7°F</td>
<td>68.3°F to 83.3°F</td>
<td>75.0°F to 90.0°F</td>
<td>81.7°F to 96.7°F</td>
<td>88.3°F to 103.3°F</td>
<td>95.0°F to 110.0°F</td>
<td>101.7°F to 116.7°F</td>
</tr>
<tr>
<td>-20°F</td>
<td></td>
<td>56.7°F to 71.7°F</td>
<td>63.3°F to 76.0°F</td>
<td>70.0°F to 85.0°F</td>
<td>76.7°F to 91.7°F</td>
<td>83.3°F to 98.3°F</td>
<td>90.0°F to 105.0°F</td>
<td>96.7°F to 111.7°F</td>
<td>103.3°F to 118.3°F</td>
</tr>
<tr>
<td>-15°F</td>
<td></td>
<td>58.3°F to 73.3°F</td>
<td>65.0°F to 78.0°F</td>
<td>71.7°F to 86.0°F</td>
<td>78.3°F to 93.3°F</td>
<td>85.0°F to 100.0°F</td>
<td>91.7°F to 106.7°F</td>
<td>98.3°F to 113.3°F</td>
<td>105.0°F to 120.0°F</td>
</tr>
<tr>
<td>-10°F</td>
<td></td>
<td>60.0°F to 75.0°F</td>
<td>66.7°F to 80.0°F</td>
<td>73.3°F to 88.0°F</td>
<td>80.0°F to 95.0°F</td>
<td>86.7°F to 101.7°F</td>
<td>93.3°F to 108.3°F</td>
<td>100.0°F to 115.0°F</td>
<td>108.3°F to 123.3°F</td>
</tr>
<tr>
<td>-5°F</td>
<td></td>
<td>61.7°F to 76.7°F</td>
<td>68.3°F to 82.0°F</td>
<td>75.0°F to 90.0°F</td>
<td>81.7°F to 96.0°F</td>
<td>88.3°F to 103.3°F</td>
<td>95.0°F to 110.0°F</td>
<td>101.7°F to 116.7°F</td>
<td>108.3°F to 123.3°F</td>
</tr>
<tr>
<td>0°F</td>
<td></td>
<td>63.3°F to 78.3°F</td>
<td>70.0°F to 83.0°F</td>
<td>77.0°F to 92.0°F</td>
<td>83.3°F to 98.0°F</td>
<td>90.0°F to 105.0°F</td>
<td>96.7°F to 111.7°F</td>
<td>103.3°F to 118.7°F</td>
<td>110.0°F to 125.0°F</td>
</tr>
<tr>
<td>5°F</td>
<td></td>
<td>65.0°F to 80.0°F</td>
<td>71.7°F to 85.0°F</td>
<td>78.3°F to 93.0°F</td>
<td>85.0°F to 100.0°F</td>
<td>91.7°F to 106.0°F</td>
<td>98.3°F to 113.0°F</td>
<td>105.0°F to 120.0°F</td>
<td>113.0°F to 125.0°F</td>
</tr>
<tr>
<td>10°F</td>
<td></td>
<td>66.7°F to 81.7°F</td>
<td>73.3°F to 86.0°F</td>
<td>80.0°F to 95.0°F</td>
<td>86.7°F to 101.0°F</td>
<td>93.3°F to 108.0°F</td>
<td>100.0°F to 113.0°F</td>
<td>106.7°F to 121.7°F</td>
<td>113.3°F to 125.0°F</td>
</tr>
<tr>
<td>15°F</td>
<td></td>
<td>68.3°F to 83.3°F</td>
<td>75.0°F to 88.0°F</td>
<td>81.7°F to 96.0°F</td>
<td>88.3°F to 103.0°F</td>
<td>95.0°F to 110.0°F</td>
<td>101.7°F to 116.7°F</td>
<td>108.3°F to 123.7°F</td>
<td>115.0°F to 128.3°F</td>
</tr>
<tr>
<td>20°F</td>
<td></td>
<td>70.0°F to 85.0°F</td>
<td>76.7°F to 91.0°F</td>
<td>83.3°F to 98.0°F</td>
<td>90.0°F to 105.0°F</td>
<td>96.7°F to 111.7°F</td>
<td>103.3°F to 118.7°F</td>
<td>110.0°F to 125.0°F</td>
<td>118.3°F to 131.7°F</td>
</tr>
<tr>
<td>25°F</td>
<td></td>
<td>71.7°F to 86.7°F</td>
<td>78.3°F to 93.0°F</td>
<td>85.0°F to 100.0°F</td>
<td>91.7°F to 106.0°F</td>
<td>98.3°F to 113.0°F</td>
<td>105.0°F to 120.0°F</td>
<td>111.7°F to 126.7°F</td>
<td>118.3°F to 131.7°F</td>
</tr>
<tr>
<td>30°F</td>
<td></td>
<td>73.3°F to 88.3°F</td>
<td>80.0°F to 95.0°F</td>
<td>86.7°F to 101.0°F</td>
<td>93.3°F to 108.0°F</td>
<td>100.0°F to 115.0°F</td>
<td>106.7°F to 121.7°F</td>
<td>113.3°F to 128.3°F</td>
<td>120.0°F to 135.0°F</td>
</tr>
<tr>
<td>35°F</td>
<td></td>
<td>75.0°F to 90.0°F</td>
<td>81.7°F to 96.0°F</td>
<td>88.3°F to 103.0°F</td>
<td>95.0°F to 110.0°F</td>
<td>101.7°F to 116.7°F</td>
<td>108.3°F to 123.7°F</td>
<td>115.0°F to 130.0°F</td>
<td>121.7°F to 136.0°F</td>
</tr>
<tr>
<td>40°F</td>
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<td>76.7°F to 91.7°F</td>
<td>83.3°F to 98.3°F</td>
<td>90.0°F to 105.0°F</td>
<td>96.7°F to 111.7°F</td>
<td>103.3°F to 118.3°F</td>
<td>109.0°F to 125.0°F</td>
<td>116.7°F to 131.7°F</td>
<td>123.3°F to 138.3°F</td>
</tr>
</tbody>
</table>
Annex D

(Informative)

Rail wear recommended 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. The following table applicable to 115RE rail is provided as a guide for maintenance practices.

<table>
<thead>
<tr>
<th>Rail Wear</th>
<th>Monitor</th>
<th>Change Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running Rail Vertical Wear (1)</td>
<td>≥ 1/2&quot;</td>
<td>≥ 5/8&quot;</td>
</tr>
<tr>
<td>Running Rail Side Wear (1)</td>
<td>≥ 3/8&quot;</td>
<td>≥ 5/8&quot;</td>
</tr>
<tr>
<td>Guard Rail Side Wear</td>
<td>≥ 1/4&quot;</td>
<td>≥ 7/16&quot;</td>
</tr>
</tbody>
</table>

(1) Wear at these levels is acceptable.
Annex E

(Informative)

Special trackwork recommended 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 gauge and adjusting it as necessary.