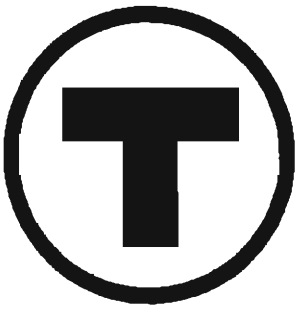

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

Maintenance of Way Division

GREEN LINE – LIGHT RAIL TRANSIT

TRACK MAINTENANCE AND SAFETY STANDARDS

Approved by: _____ Date: _____
Sr. Project Manager for R.O.W. Maintenance

Approved by: _____ Date: _____
Deputy Director – Rail Systems

Approved by: _____ Date: _____
Director - Systemwide Maint. and Improvements

INTRODUCTION

The LRT (Light Rail Transit) Track Maintenance and Safety Standards are published by the Maintenance of Way Division of the MBTA. They are published for the purpose of maintaining the rail facilities of the MBTA to a standard which will ensure the safety of the riding public and of the employees of the MBTA.

These Standards are supplemented by previously issued MBTA documents including the M.O.W. Division's Safety Rules, Flagging and Train Protection Policy, Right-of-Way Safety Rules, Power Switching Policy, MBTA General Rules and others contained in the Standards' Appendices.

The Director, Systemwide Maintenance and Improvements is responsible for the development of the Standards. Implementation of the Standards is the responsibility of the Superintendents, Supervisors and Forepersons of the Maintenance of Way Division.

Compliance with the Standards is the responsibility of every member of the M.O.W. Division. All personnel should familiarize themselves with the requirements of the Standards and conduct themselves accordingly.

Mark G. O'Hara
Rail Transit Consultant –
Design, Construction and
Maintenance of Track Facilities

March, 2000

MBTA

MAINTENANCE OF WAY DIVISION

LRT Track Safety and Maintenance Standards

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Appendices D and E are not included in these LRT Standards. They can be found in the Blue, Orange and Red Line (HRT) Standards.

LRT213 – Track Maintenance and Safety Standards

PART A – GENERAL

LRT213.1 Scope.

This section prescribes minimum maintenance and safety requirements for transit railroad track on the MBTA's Green Line. The requirements prescribed in this section apply to specific track conditions existing in isolation. Therefore, a combination of track conditions, none of which individually amounts to a deviation from the requirements of this section, may require remedial action to provide for safe operations over the track.

LRT213.2 DTE Regulations.

Inspection and maintenance of MBTA track is regulated by the Commonwealth of Massachusetts' Department of Telecommunications and Energy under M.G.L. c. 30A. The DTE regulations will dictate inspection and maintenance standards except as modified by the MBTA standards to be more stringent than DTE regulations.

LRT213.3 Application.

The track maintenance and safety standards contained herein are designed to enable the operation of trains at the maximum safe speed for the track over which the trains are operating.

Trains may be operated safely at a lower speed than that posted based upon parameters given within the Standards. Certain track defects are categorized by severity thresholds identified within the Standards. Color-coded maintenance threshold limits are used to govern reaction to detected track defects.

GREEN coded track conditions are not exceptions to the MBTA Track Maintenance Standards and do not necessarily require immediate remedial action. GREEN coded conditions should be, at a minimum, verbally communicated to the responsible Section Foreman and/or Supervisor. This level condition should be monitored on an ongoing basis for deterioration to the next level.

YELLOW coded track conditions have reached or are closely approaching the maintenance limit for train operation at normal posted speed. As such, YELLOW coded conditions are classified as track defects and remedial action should be scheduled to correct the deficiency before it escalates to the next level.

RED coded track conditions are defects which generate speed restrictions (slow orders) and at the most severe level are grounds for removing effected track from service until repairs can be made. In most cases, RED coded defects should be scheduled for immediate remedial action. These defects are by definition the highest repair priority.

The intent of the Standards is not to establish artificially rigid procedures governing track maintenance but rather to serve as guidelines for prudent track maintenance practice. These guidelines must be used in concert with proper exercise of judgment based upon experience and knowledge of service requirements.

The track maintenance guidelines are intended to apply to normal operating conditions. During maintenance activities or under temporary conditions, interim modifications of the Standards may be required and would be subject to existing site conditions.

LRT213.4 Track Maintenance Strategies and Light Rail Vehicle Historical Notes

The MBTA has had over 20 years experience with operation of articulated Light Rail Vehicles (LRVs).

The first generation LRV(Boeing) was designed with two motorized trucks front and rear and an non-powered center truck which was loaded to only about 50% of the weight supported by the end trucks. The suspension characteristics of this vehicle made it stable at cruising speed but susceptible to wheel climb derailments at low speed. This susceptibility was due to the trucks' rotational resistance or "curving" ability in lower radius curves.

The second generation LRV (Kinki Sharyo) also was designed with two motorized trucks front and rear and an non-powered center truck under the articulating section of the car. The vehicle's weight was distributed more evenly than in the Boeing car (35% on each end truck and 30% over the center truck). The suspension was modified for greater truck "curving" ability at low speed in sharp curves. At cruising speed, however, the Kinki LRV was less stable than the Boeing LRV.

The MBTA's experience has demonstrated that LRVs by both manufacturers are far more demanding from a track maintenance standpoint than the former MBTA Green Line standard, the PCC (President's Conference Committee) car. The PCC car was designed with the same ATEA wheel as the modern LRVs, but with a totally different suspension system. The PCC car was routinely, successfully operated through unguarded special trackwork and over track throughout the MBTA Green Line which the LRVs were incapable of navigating. As a result, much of the Green Line track system was upgraded to accommodate the LRVs.

Certain track conditions and maintenance practices which would otherwise be perfectly acceptable should be avoided to the greatest extent possible on the Green Line. These conditions/practices have been implicated in past derailments in which vehicle and/or operator deficiencies were also involved.

A combination of track conditions, especially YELLOW coded conditions, can act in concert with operator error and/or vehicle malfunction to cause a derailment. This is especially true in special trackwork, where the overwhelming majority of derailments occur. Conditions such as negative superelevation, irregular track surface and/or alignment, abrupt gage transitions, non-uniform wheel restraint, poorly finished gage side welds and others which may create a dynamic imbalance in certain operating environments should be closely monitored.

When performing maintenance operations in LRT track, especially LRT track worn close to permissible limits through repeated normal use, a very important principle must be kept in mind. *Adjustments made to, or components replaced on one side of a switch or curve will have a direct and substantial effect on the opposite side of the switch or curve.* Care must be exercised to ensure that existing conditions are not put into an imbalanced state through well intentioned and well executed maintenance work. Imbalance of track conditions through maintenance of only one side of worn track leads to differential distribution of vehicle forces which may result in wheel climb, component failure and derailment.

Under certain circumstances, logistical constraints make it impossible to perform maintenance activities so that track conditions do not become imbalanced. In such circumstances, it is almost always preferable to work on the inside of the switch or curve first. Experience has shown that lateral wheel forces are far more successfully managed by restraint to the back of the inside wheel flange than at the gage corner of the outside wheel. One caution: when renewing rail and re-establishing proper wheel restraint on the inside of curves, be sure that the outside wheel will not be "pulled off" the outside rail. This is particularly true where the outside gage face is worn. The use of test trains and speed restrictions is almost always warranted in cases of unavoidable imbalanced track conditions.

LRT213.5 Responsibility for Compliance with Track Maintenance Standards

Reported defects must receive prompt investigation and corrective action as required. Emergency conditions detected which constitute or should reasonably constitute an immediate safety hazard must be acted upon.

On occasion where the responsible M.O.W. Div. personnel knows or has responsible notice from other sources that a track condition is in violation of the Standards herein and the safe operation of trains is potentially jeopardized, the following steps must be taken:

1. Reduce the operating speed of trains to the level where track conditions are compliant with the Standards (REFER TO SMI SPECIAL ORDER #98-2 FOR INSTITUTING SPEED RESTRICTIONS AND ENSURE THAT PROPER NOTIFICATION FORM HAS BEEN FILLED OUT AS REQUIRED); or

2. Repair the track to support normal train operation; or

3. Stop train traffic over impacted track.

LRT213.6 Restricted Speed Rules.

Any track condition which may interfere with the safe operation or passage of trains is considered an "obstruction". Protection shall be provided for any track which is obstructed or not considered safe for the passage of trains at the normal, posted operating speed. Protection shall be provided as outlined in SMI Special Order #98-2 (Appendix A). Proper notification must be given using Restricted Operation Notification form (Appendix B). *It is critical that the M.O.W. person responsible for the placement of a restricted speed order remain at the scene until the appropriate speed signs are in place and/or a Subway Operations official has arrived on the scene to provide relief.*

The limit to which speed should be restricted due to defects and/or abnormal track conditions is indicated within the Standards.

LRT213.7 Designation of Personnel to Supervise Track Maintenance Activities and to Inspect Track.

The qualifications required of M.O.W. persons involved in the supervision of track maintenance activities and track inspection are contained in the DTE regulations under section 151.08 (4).

Persons not qualified to supervise certain maintenance activities or to inspect track as outlined in DTE regulations but with at least one year of M.O.W. experience, may pass trains over broken rails and/or pull-aparts provided that-

1) The person is qualified to do so as a result of being trained and has been examined and re-examined within two years after each prior examination on the following topics as they relate to the safe passage of trains over broken rails and/or pull-aparts: rail defect identification, crosstie condition, track surface and horizontal alignment, gage restraint, rail end mismatch, joint bar integrity and the maximum distance between rail ends over which trains may be allowed to pass. A minimum of four hours is adequate for initial training;

2) The person determines that it is safe and train speeds are limited to a maximum of 10 m.p.h. over the defect;

3) The person shall personally watch all movements over the defect and be prepared to stop trains if necessary; and

4) Persons fully qualified under DTE regulations are notified and dispatched to the location promptly for the purpose of authorizing continued train movements and performing temporary or permanent repairs.

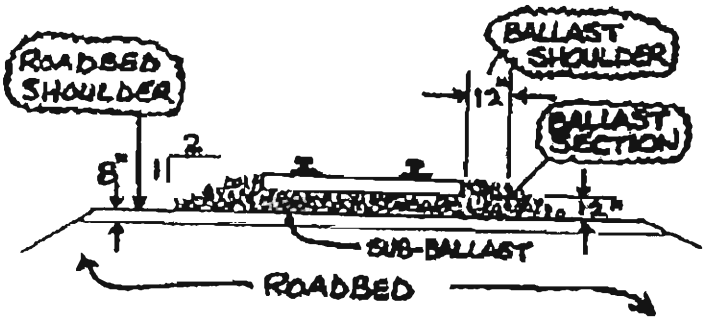
LRT213.13 Measuring Track Not Under Load.

When unloaded track (static condition) is measured to evaluate compliance with the requirements of these Standards, any apparent rail movement (both vertically and horizontally) must be added to the measurements of the unloaded track. The resulting product (dynamic condition) will be used to determine compliance with the Standards.

PART B – ROADBED

LRT213.31 Scope.

This section prescribes minimum requirements for roadbed and areas immediately adjacent to roadbed. Roadbed consists of the area beneath the track structure which supports the track structure, absorbs loads transmitted from the track structure and is subject to the deteriorating effects of cyclical traffic loads.



Periodic maintenance is required to restore roadbed shoulders to their original configuration to ensure the roadbed drains properly and supports the loads transmitted to it by the track structure. Ditches need to be kept free of vegetation and debris. Un-maintained ditches lead to flooding conditions and destroy the integrity of the track structure.

LRT213.33 Drainage.

Proper drainage from the track structure is critical to the performance of the track structure. Improperly drained track becomes unstable and maintenance-intensive. Maintenance programs should be in place to keep all drainage facilities beneath and adjacent to the track free from obstructions and able to accommodate the expected water flow for the area served by the drainage facilities.

Within tunnels and/or subway structures, defects which result in water falling onto track components should be repaired as soon as possible. Water must be diverted to a drainage system or the leak sealed.

LRT213.37 Vegetation.

Vegetation on MBTA property which is within or immediately adjacent to the track area must be controlled. Vegetation is a deterrent to drainage and causes a wide range of problems within the right-of-way. Some consequences of failure to control vegetation are:

(a) Fouled roadbed and ballast sections from roots and vines.

(b) Fire hazard, especially in dry weather or in the autumn.

(c) Obstructed visibility with respect to wayside signals, speed signs, etc.

(d) Safety hazard due to line-of-sight interference for operating personnel.

(e) Interference to employees performing track, power or signal duties.

(f) Improper functioning of signal and communication equipment.

PART C – TRACK GEOMETRY

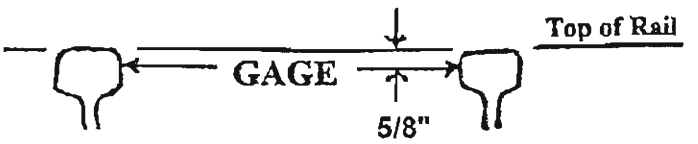
LRT213.51 Scope.

This section prescribes requirements for the maintenance limits for track gage, track alignment, track surface, track crosslevel, spiral track geometry, clearances and speed limitation in curved track.

LRT213.53 Gage.

For Tee Rail Sections Only (85 ASCE and 115 RE)

For LRT track (Green Line), gage is measured between the heads of the rails at right angles to the rails in a plane five eighths of an inch (5/8") below the tops of the rail heads.



GAGE MEASUREMENT FOR LRT TRACK

When measuring track gage, the gage dimension is the *total* of the actual distance measured plus any apparent rail movement caused by train loading and/or any sidewear to the rail(s). As gage is measured 5/8" below the tops of the rail heads, sidewear to the rails is also measured 5/8" below the tops of the rail heads (LRT track only).

Minimum track gage in LRT track is: 56-3/16" for tangent track, 56-5/16" for curves 100'R to 1000'R and 56-1/2" for curves less than 100'R (including special trackwork).				
MAXIMUM GAGE LIMITS FOR LRT TEE RAIL TRACK				
Track Configuration	Design Gage	**Maintenance Threshold Limits Response Actions**		
		Green	**Yellow**	**Red**
Tangent	56-1/2"	56-7/8"	57-1/8"	57-3/8"
Curves >1000'R	56-1/2"	57" Monitor – note on inspection report.	57-1/4 Restrict speed to 25 mph. Schedule repairs.	57-1/2" Restrict speed to 10 mph. Repair within 24 hours."
Curves 125'R - 1000'R (Single restraining rail, flangeway = 1-5/8").	56-7/8"	57-1/4" Monitor – note on inspection report.	57-1/2" Restrict speed to 15 mph. Schedule repairs.	57-5/8" Restrict speed to 5 mph. Repair within 24 hours.
Curves less than 100'R (Double restraining rail, both flangeways = 1-1/2").	56-3/4"	57-1/4" Monitor – Note on inspection report.	57-1/2" Restrict speed to 10 mph. Schedule repairs.	57-3/4" Restrict speed. to 5 mph. Repair within 24 hours

MAXIMUM GAGE LIMITS FOR LRT TEE RAIL TRACK (Continued)				
Track Configuration	Design Gage	Maintenance Threshold Limits Response Actions		
		Green	**Yellow**	**Red**
Guarded switches over 100'R	56-7/8" curved side 56-1/2" straight side	57-1/8" 57" Monitor – Note on inspection report.	57-3/8" 57-1/4" Restrict speed to 5 mph. Repair before red limit is reached.	57-1/2" 57-1/2" Supervise operations through switch until repairs completed.
Flangeway at cover guard to be 1-5/8" (to gage line of double switch point thrown for straight move). Flangeway throughout rest of turnout to be 1-5/8" except one-piece guard rails opposite frogs that have flangeway of 1-3/8". Remedial flangeway work to be initiated at 1-7/8" in turnouts. Refer to **LRT213.143** for guard check and guard face criteria.				
Guarded switches 100'R or less	57" curved side 56-1/2" straight side	57-1/4" 57"	57-1/2" 57-1/4"	over 57-1/2" 57-1/2"
		Response actions same as for switches over 100'R.		
(Refer below for flangeway notes and maintenance criteria.)				

Flangeway at cover guard to be 1-1/2"* (to gage line of double switch point thrown for straight move). Flangeway throughout rest of turnout to be 1-5/8" except one-piece guard rails opposite frogs that have flangeway of 1-3/8". Remedial flangeway work to be initiated at 1-3/4"** through cover guard and at 1-7/8" throughout rest of turnout. Refer to **LRT213.143** for guard check and guard face criteria.

Notes:

= Flangeway may be reduced to 1-1/4" in special circumstances where wheel climb at outside, single point is an issue due to geometric design constraints.

** = Where flangeway has been reduced below typical, remedial work is to be initiated at 1/4" greater than original flangeway opening.

Track Configuration	Design Gage	Maintenance Threshold Limits Response Actions		
		Green	**Yellow**	**Red**
Rail crossings (Diamonds) with curves less than 100'R	56-3/4" curved.	57"	57-1/4"	57-1/2"
	56-1/2" straight	57"	57-1/4"	57-1/2"
		Monitor – Note on inspection report.	Restrict speed to 5 mph. Repair before red limit is reached.	Supervise operations through crossing until repairs completed
Flangeways on curved side of crossing to be 1-1/2" throughout, both inside and out; Flangeways on straight side to be 1-3/8" throughout, both inside and out.				
Rail crossings (Diamonds) with curves 100'R - 1000'R	56-7/8" curved	57-1/8"	57-3/8"	>57-1/2"
	56-1/2" straight	57"	57-1/4"	57-1/2"
		Monitor – Note on inspection report.	Restrict speed to 5 mph. Repair before red limit is reached.	Supervise operations through crossing until repairs completed.
Flangeways on curved side of crossing to be 1-1/2" through frog castings inside rail, 1-5/8" through frog castings outside rail and 1-5/8" elsewhere, both inside and out; Flangeways on straight side to be 1-3/8" throughout, both inside and out.				

General Notes:

Transitions in track gage shall be at the rate of 5/8" in no less than 31', except in special trackwork and when entering/leaving restrained curves, which shall be as shown in the Design Standards. Under ordinary conditions it will not be necessary to regage track if it is within limits indicated for the track in question and does not exceed standard for uniformity. Gage conditions exceeding the limits must be corrected immediately. A combination of marginal track conditions may mandate corrective action before the maintenance limit for any individual parameter is reached.

Deteriorating track gage conditions not corrected until maintenance limits are reached will result in increasingly accelerated degradation of the track structure. Attention to deteriorating track gage conditions will result in longer-lived track and will in most cases prevent the need for critical repairs to maintain acceptable gage.

LRT213.54 Flangeway Width.

For Tee Rail Sections Only (85 ASCE and 115 RE)

Standard flangeway width for LRT track is 1-5/8". Refer to **LRT213.53** for flangeway criteria for double restrained track and in special trackwork. Nominal flangeway depth through flange bearing special trackwork is 11/16". Maintenance threshold limits for flangeway width are given under **LRT213.116** except where modified for switches in **LRT213.53**.

LRT213.55 Horizontal Track Alignment.

Definition: horizontal track alignment consists of a series of tangent (straight) lengths of track connected by curves. Curves are either simple (same radius throughout) or compound (different radii within the same curve). Spiral curves are used to connect simple curves to tangent track or a simple curve to another simple curve. Spiral curves provide a gradual transition between changes in track alignment and accommodate runoff of SE. This is done to allow vehicle (train) trucks (sets of wheels) to gradually rotate entering or leaving curves. Spiral curves both reduce rail/wheel wear and result in a smoother, safer ride.

LIMITS OF DEVIATION FROM UNIFORM HORIZONTAL TRACK ALIGNMENT								
Measurement Parameter for Tangent Track: The deviation at the middle of a			**Measurement Parameter for Curved Track:** The deviation from a calculated mid-ordinate of a					
62' Chord*			**31' Chord****			**62' Chord****		
Maintenance Threshold			**Maintenance Threshold**					
Green	**Yellow**	**Red**	**Green**	**Yellow**	**Red**	**Green**	**Yellow**	**Red**
1"	1-1/2"	2-1/4"	3/4"	1"	1-1/2"	1"	1-1/2"	2-1/4"

Response Actions for exceptions to color-coded maintenance thresholds for horizontal track alignment:

Green: monitor conditions – make note of exception on inspection report.

Yellow: restrict speed over track to 25 mph – schedule repairs to be done within 72 hours.

Red: restrict speed over track to 10 mph – make repairs within 24 hours.

Note: Train operation through line deviations exceeding the red maintenance threshold may be manually supervised (walked through) at the discretion of the M.O.W. Line Supervisor or Superintendent on site based on their assessment of track fitness.

Note:

*The ends of the 62' chord shall be at points on the gage side of the line rail, 5/8" below the top of the rail head. Either rail may be used as the line rail provided that the same rail is used for the entire length of the tangent segment of track.

** The ends of the 31' and 62' chords shall be at points on the gage side of the outer rail (line rail on curves), 5/8" below the top of the rail head.

LRT213.57 Curves; Superelevation and Speed Limitations.

Definitions: *superelevation* (or elevation) is the amount the outer rail of a curve is raised above the inner rail. This is known as Ea or actual elevation. Its function is to counteract the effect of centrifugal force. *Equilibrium* (or balanced elevation) is the amount of superelevation in a curve which exactly counterbalances the effect of centrifugal force in that curve for the designated speed in the curve. This is known as Ee. or equilibrium elevation. *Unbalanced* elevation is the amount of elevation less than that required to achieve equilibrium in a curve for the designated speed. This is known as Eu. or unbalanced elevation. *Overbalanced* elevation is the amount of elevation more than that required to achieve equilibrium in a curve for the designed speed.

Actual elevation equals equilibrium elevation minus unbalanced elevation, if any, or Ea = Ee. - Eu.

The maximum actual superelevation (Ea) on the outside rail of a curve may not be more than 6-1/2" throughout the system. The amount of unbalanced elevation (Eu.) may not be more than 3". The outside rail of a curve may not be lower than the inside except as provided in **LRT213.63**. To calculate equilibrium elevation required for a given curve, use the following formula:

$$Ee=4.011xV^2/R$$

Where:

Ee. = Superelevation (equilibrium elevation) in inches.
V = Speed (velocity) in miles per hour.
R = Radius of curve in feet.

Track surface, including superelevation, shall be maintained so that variations in profile, runoff and crosslevel do not exceed the limits in the table at **LRT213.63**. Immediate speed restriction and corrective action are necessary when the limits are exceeded.

LRT213.59 Elevation of Curved Track; Runoff.

Elevation occurring in a curve shall be provided uniformly throughout the curve unless physical conditions do not permit. If elevation runoff is required in a curve, the actual minimum elevation shall be used to compute the maximum allowable speed for that curve under **LRT213.57**. Elevation runoff shall be at a uniform rate, within the limits of track surface deviation under **LRT213.63**, and shall extend at least the full length of the spiral(s). If the length of spiral is limited by physical conditions, part of the SE runoff may occur on tangent track up to a limit of 1".

LRT213.63 Track Surface.

LIMITS OF DEVIATION FROM UNIFORM TRACK SURFACE			
Measurement Parameter	**Maintenance Threshold**		
	Green	**Yellow**	**Red**
Runoff in any 31' of rail at the end of a raise.	1-1/4"	1-1/2"	2-1/2"
Deviation from uniform profile on either rail at the mid-ordinate of a 62' chord.	1-5/8"	2"	2-1/2"
Variation in cross-level on spirals in any 31' maximum.	7/8"	1"	1-1/2"
Deviation from zero crosslevel at any point on tangents or reverse crosslevel on curves.	1-1/8"	1-1/4"	1-7/8"
Difference in crosslevel between any two points less than 62' apart on tangents and on curves between spirals.	1-5/8"	1-3/4"	2-1/8"

Response Actions to Deviations		
Green	**Yellow**	**Red**
Monitor situation on an ongoing basis. Advise supervisory personnel.	Restrict speed to 25 mph. Schedule surfacing operation within 72 hours.	Restrict speed to 10 mph. Surface track in violation immediately.

LRT213.65 Clearances.

Specific minimum clearances must be maintained between trains and wayside/overhead structures and facilities. When surfacing and/or lining track or when engaged in out-of-face track reconstruction, attention shall be given to the preservation of existing clearances. Pantograph to catenary relationship must also be carefully considered when horizontal track shifts or changes in superelevation are contemplated. A one inch (1") change in crosslevel can translate into up to five inches (5") of lateral pantograph shift at the catenary.

The preferred minimum horizontal clearance measured from the centerline of track on tangent alignment is 7'-6". An absolute minimum of 6'-0" on tangent alignment may be used in extreme cases where absolutely necessary. In either case, and even more importantly in curved track, consideration of curvature, superelevation, car body roll, car body suspension related lateral displacement and vehicle overhang must be taken when calculating required clearances.

Every effort should be made to preserve existing vertical clearance when planning track maintenance or construction activities. In the event where overhead clearance will be reduced due to proposed track structure changes or for other reasons, a clearance survey of existing conditions should be undertaken using an actual vehicle if possible. This is especially critical in areas of low wire height. Pantograph "lockdown" could result from track lifts in low wire height territory. Potential clearance obstructions should be located relative to vehicle's dynamic clearance envelope on reconfigured track. Under no conditions should any obstruction be allowed to encroach within 3" of the dynamic clearance envelope, a minimum of 6" is preferred.

The preferred minimum horizontal distance between LRT centerlines on tangent alignment is 12'-0". Absolute minimum is 11'-0". In any case, the clearance between dynamic envelopes of vehicles on adjacent tracks shall be no less than 6" after taking all factors (curvature, etc.) into account.

PART D - TRACK STRUCTURE

T213.101 Scope.

This section prescribes minimum requirements for ballast, crossties, fastening assemblies and the physical condition of rails including restraining rail.

T213.103 Ballast.

Unless the track is structurally supported in another fashion (i.e., concrete slab, steel stringer, etc.), it shall be supported by material (crushed granite ballast) which will meet the following requirements:

a) Transmit and distribute static track loads and loads from passing trains to the subgrade;

b) Provide lateral, longitudinal and vertical restraint under dynamic loads imposed by passing trains and from thermal stress exerted by the rails during extremes in temperature;

c) Provide proper drainage of the track structure; and

d) Facilitate the maintenance of track line, surface and crosslevel.

Ballast used on the Green Line shall be A.R.E.A. No. 4
(sieve opening 3/4" to 1-1/2") unless otherwise specified. Ballast received from suppliers that is of inferior quality, the wrong grade or contains dirt or other contaminants (fines) shall be rejected.

Refer to typical track structure cross-section under **LRT213.31** - ROADBED. A ballast section that provides a ballast shoulder measuring 12" from the end of tie to the top of slope and a ballast slope of 2:1, is highly desirable. Under no circumstances should the ballast shoulder measure less than 6" horizontally. The ballast level in the tie cribs (area between the ties) should be maintained even with the top of ties or no less than 1" below the tops of ties.

Insufficient or improperly sloped ballast shoulders and/or tie cribs not adequately filled with stone make track susceptible to unwanted movement including possible buckling under high stress. Track which is in improper ballast condition (<6" shoulder, more severe than 2:1 shoulder slope and/or cribs lower than 1" from top of tie level) should receive immediate attention and speed should be restricted until repairs can be made.

Track which has been substantially disturbed through lining or especially surfacing or by any other means whereby the adhesion between ties and ballast has been broken, must be inspected prior to the resumption of train operations. The inspection must be conducted by a person designated under **LRT213.7** and should focus on the presence of sufficient and properly placed ballast to support train operations at the posted speed.

LRT213.109 Crossties.

Crossties used on the Green Line shall be 7" x 9" x 8'-6", 100% hardwood and shall conform to the requirements of the AREMA Specifications for Timber Crossties. All crossties shall be equipped with approved anti-splitting devices per the AREMA. Specifications.

All tracks shall have a sufficient number of crossties which in combination provide effective support and shall:

a) Hold gage within the limits prescribed in **LRT213.53**;

b) Maintain track surface within the limits prescribed in **LRT213.63**; and

c) Maintain horizontal alignment within the limits prescribed in **LRT213.55**.

Each 39' section of track shall have the minimum number of non-defective crossties as indicated in the table on the following page. To satisfy the requirements set forth in the table, crossties must not be:

1) Broken through - a crosstie with a *vertical* break *completely through* the thickness of the tie;

2) Split or otherwise impaired to the extent that ballast from beneath the tie has worked through or spikes may be pulled from the tie easily by hand;

3) Deteriorated to the extent that the tie plate or rail base (in the absence of a plate) moves laterally under dynamic loading more than ½" relative to the tie's surface; or

4) Cut by the tie plate (or rail base) more than 15% (nominally 1-1/8") of the tie's thickness.

5) Incapable of maintaining gage, horizontal and/or vertical alignment as described above.

Response Action to tie maintenance threshold criteria shown below.		
Green	**Yellow**	**Red**
Monitor tie conditions. Notify line supervisory personnel of any deterioration of conditions.	Restrict speed to 25 mph. Schedule tie renewal within 10 days.	Restrict speed to 10 mph. Replace defective ties within 72 hours.

Measurement Parameter:

MINIMUM NUMBER OF NON-DEFECTIVE CROSSTIES PER 39' OF TRACK

Maintenance Thresholds:

Green		Yellow		Red	
Tangent	Curved*	Tangent	Curved*	Tangent	Curved*
10	12	8	9	5	6

Measurement Parameter:

MAXIMUM DISTANCE BETWEEN NON-DEFECTIVE TIES (CTR. TO CTR.) BASED ON 24" TIE SPACING

Maintenance Thresholds:

Green		Yellow		Red	
Tangent	Curved*	Tangent	Curved*	Tangent	Curved*
72"	48"	96"	72"	120"	96"

Measurement Parameter:

MAXIMUM NUMBER OF SUCCESSIVE DEFECTIVE TIES (BASED ON 24" TIE SPACING)

Maintenance Thresholds:

Green		Yellow		Red	
Tangent	Curved*	Tangent	Curved*	Tangent	Curved*
2	1	3	2	4	3

*Indicates curves less than 1500' radius.

In jointed track:

To support train speed up to 25 m.p.h., track shall have one non-defective crosstie whose centerline is within 24" of each joint location. To support train speeds up to 50 m.p.h. (system speed limit), track shall have one non-defective crosstie within 18" of each joint location or, two non-defective crossties whose centerlines are within 24" either side of each joint location. Speed for track not meeting this criteria shall be restricted per **LRT213.6**.

For track constructed without crossties, such as concrete slab track, track with rails directly connected to bridge structural components or track over inspection/service pits, the track structure shall meet the requirements for gage in **LRT213.53**, track surface in **LRT213.63** and track alignment in **LRT213.55**.

LRT213.113 Defective Rails.

When it is learned, through inspection or by other means, that a rail in track contains any of the defects listed in the table on the following page, a M.O.W. person designated under **LRT213.7** shall determine whether trains may continue to operate over the track. If it is determined, after careful inspection, that the track may continue to support train operations, such operations are not permitted until the remedial action prescribed in the following tables is initiated:

DEFECTIVE RAILS AND REMEDIAL ACTION			
	Defect Size (% of rail head cross section)	Until Defective Rail is replaced	
Defect	From To	Remedial action to be taken	Maximum speed
Detected Transverse Defects in Non-control Cooled Rail and Transverse Fissure or Compound Fissure	0 99	Limit operating speed to –	10 mph
	100%	Visually inspect track after each supervised operation over rail.	5 mph
Detected Transverse Defects in Control Cooled Rail -or- Detail Fracture	0 19	Apply joint bars to defect within 20 days (omit middle bolt holes) Until joint bars are applied, limit speed to –	30 mph
Defective Weld Engine Burn Fracture	20 99	Apply joint bars to defect within 10days (omit middle bolt holes) Until joint bars are applied. limit speed to –	10 mph
Broken Rail as a Result of Defects Listed Above	100%	Apply joint bars with two bolts on each side of defect Until bars are installed, supervise train operation and limit speed to –	5 mph
Horizontal Split Head Vertical Split Head	0" - 2"	Inspect rail every 90 days for defect propagation	50 mph
	2" - 4"	Inspect rail every30 days and limit speed to –	30 mph
	over 4"	Limit speed to –	10 mph
	break-out in rail head	Visually super-vise each operation over rail	5 mph

DEFECTIVE RAILS AND REMEDIAL ACTION (Continued)			
	Defect Size	Until Defective Rail is replaced	
Defect	From To	Remedial action to be taken	Maximum speed
Split Web Piped Rail Head & Web Separation	0" ½"	Inspect rail every 90 days for defect propagation	50 mph
	½" 3"	Inspect rail every 30 days and limit speed to –	30 mph
	over 3"	Limit speed to –	10 mph
	break-out in rail head	Visually supervise each operation over rail	5 mph
Bolt Hole Crack	0" ½"	Inspect rail every 90 days for defect propagation	50 mph
	½" 1-1/2"	Inspect rail every 30 days and limit speed to –	30 mph
	over 1-1/2"	Limit speed to –	10 mph
	break-out in rail head	Visually supervise each operation over rail	5 mph
Broken Base	0" 6"	Apply joint bars with two bolts on each side of defect and limit speed to	30 mph
	over 6"	Replace rail	–
Ordinary Broken Rail		Apply joint bars with two bolts on each side of break, speed after bars are installed to be	50 mph
		Until joint bars are installed, supervise each train over break and limit speed to	5 mph
Damaged Rail		Apply joint bars to defect within 20 days, until bars are installed limit speed to –	30 mph
		After installation of bars, limit speed to	50 mph

Notes:

1) Inspections called for in Defective Rail tables to be performed by person as designated under **LRT213.7.**

2) Transverse defects, transverse and/or compound fissures can not be verified until rail is removed from track and fracture faces of the defect examined.

3) In temporarily repairing defects through the use of joint bars as prescribed in the Defective Rail tables, 6 hole bars are to be used and the middle 2 holes of the bar are not to be used nor is the rail to be drilled.

Defective rails and welds should be cut out of track using a rail saw whenever practically possible. Torch cutting should not be done except under emergency circumstances. Torch cut rails should not be operated over at more than 10 mph and must be removed from track as soon as possible. The minimum length rail installed in track should be 18' except in emergency situations. Field welds made in CWR shall be inspected for internal defects by a qualified inspector.

ADDITIONAL DEFECTIVE RAIL CONDITIONS AND REMEDIAL ACTION PRESCRIBED		
Condition	When a determination for replacement is made by a person designated under **LRT213.7**	When a determination is made by a person designated under **LRT213.7:** that replacement is not required at this time:
Shelly spots Head checks Engine burn (no fracture)	Limit speed to 20 mph and schedule rail replacement.	Inspect rail for internal defect at least once a year.
Flaking Slivered Corrugations Corrosion		Inspect rail for internal defects at least once every 6 months.
For definitions of defect conditions as outlined in **LRT213.113** on pages 20 through 24 refer to Appendix D.		

LRT213.114 Rail Wear.

For Section 115 RE:
Rail may remain in service until the horizontal head wear limit is reached provided that track gage is within limits described in **LRT213.53**. **The maximum amount of horizontal head wear (sidewear) allowable is 13/16".** The resulting minimum amount of remaining rail head (measured as indicated in Figure **LRT213.114**) for rail in service is 1-7/8". **The maximum amount of vertical rail wear permissible is 7/8".**

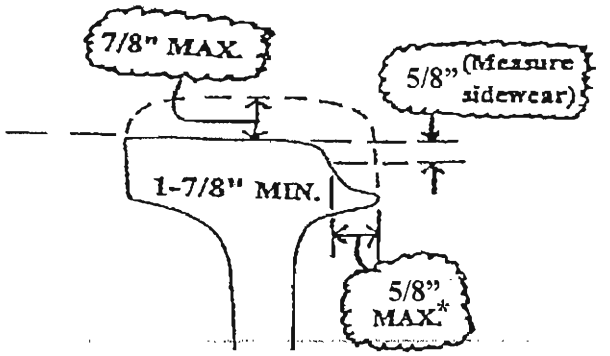


Figure LRT213.114
Rail Wear Measurements

*Note: When side wear equals or exceeds ½", schedule rail for replacement.

LRT213.115 Rail End Mismatch.

Any mismatch of rails at joint locations may not be more than that prescribed in the following table. Mismatches can be due to different rail wear levels between two joined pieces of rail, rail-end batter on either or both rails or worn joint bars.

RAIL END MISMATCH MAINTENANCE LIMITS					
Measurement Parameters:					
Vertical mismatch on the tread of the rail ends			**Horizontal mismatch on the gage side of the rail ends**		
Maintenance Thresholds:					
Green	**Yellow**	**Red**	**Green**	**Yellow**	**Red**
3/16"	5/16"	7/16"	1/8"	3/16"	1/4"
Response Actions:					
Green (G): Monitor conditions, notify supervisory personnel of situation.					
Yellow(Y): Restrict speed to 25 mph, schedule repairs to be done within seven (7) days.					
Red(R): Restrict speed to 10 mph, make repairs within forty-eight (48) hours.					

LRT213.116 Restraining Rail.

DEFINITION: Head-hardened or fully heat-treated 132 RE rail mechanically fastened (bolted through the web) to the inside running rail of curves.
FUNCTION: Primary - to reduce rail wear to the outside rail of curves; secondary - to reduce the chance of wheel climb up the gage face and over the outside rail of curves.

Restraining rail is installed with a specified flangeway clearance (refer to **LRT213.54**) to the gage side of the inside running rail. The restraining face of the restraining rail is toward the gage side of the inside

running rail and, when properly adjusted, maintains constant contact with the back of vehicle flange as trains travel through curves.

Restraining rail maintenance typically involves adjustment of the flangeway width and/or replacement of broken spacer block assembly components, particularly bolts. **Maintenance threshold limits for flangeway width are: Green - 1-3/4", Yellow - 1-7/8" and Red - 2"**. Maintenance threshold limits for restraining rail bolt breakage are shown in the following table.

MAINTENANCE THRESHOLD LIMITS RESTRAINING RAIL BOLTS					
Measurement Parameters:					
Consecutive Broken Bolts			**Total Broken Bolts in any 39' of Track**		
Maintenance Thresholds:					
Green	**Yellow**	**Red**	**Green**	**Yellow**	**Red**
2	3	4	5	6	7
Response Actions:					
Green: Monitor conditions. **Yellow:** Restrict speed to 25 mph if immediate repairs cannot be made, advise supervisory personnel; execute spot bolt replacement within 24 hours to upgrade speed, schedule wholesale bolt re-torquing/replacement in curve to be done within 7days. **Red:** Restrict speed to 10 mph until emergency bolt replacement is accomplished to upgrade speed; notify supervisory personnel, schedule wholesale bolt re-torquing/replacement in curve to be done within 72 hours.					

LRT213.119 Continuous Welded Rail (CWR).

Continuous welded rail is designated by the initials CWR in this section. CWR is defined as a group of 39' (usually) or 78' rails welded together to form a rail "string". By definition, a rail "string" of at least 400' in length is CWR. Track constructed with CWR strings is called "CWR track".

CWR must be installed and adjusted in accordance with the Authority's *"CWR Installation Guide and Track Buckling Countermeasures Policy"*. (Refer to Appendix "G" at the end of these Standards). After installation of CWR, disturbance of the track structure should not take place at rail temperatures higher than the CWR installation or adjusted (de-stressed) installation temperature, except as provided in the aforementioned *"CWR Installation Guide and Track Buckling Countermeasures Policy"*.

LRT213.121 Rail Joints.

Bolted rail joints provide structural continuity by transferring lateral and vertical wheel loads between adjacent rails with no relative movement of abutting rail ends. Properly functioning joints permit longitudinal movement within the joint bars to accommodate expansion and contraction of rails due to thermal and/or mechanical stresses.

a) Each rail joint, insulated joint and compromise joint shall be the proper design and dimensions for the rail section on which it is used.

b) If a joint bar is cracked, broken or because of wear allows vertical movement of either rail when all bolts are tight, it must be replaced.

c) If a joint bar is cracked or broken between the middle two bolt holes, it must be replaced.

d) If both bars of a joint are cracked or broken between the middle two bolt holes or one of the bars is found to be broken completely through, an appropriate speed restriction (see page 28) must be placed on the track until the bar(s) can be replaced.

e) If both bars are found to be broken completely through between the middle two bolt holes, trains may operate over the joint only under the visual supervision of a person designated under **LRT213.7** until the bars are replaced.

f) In conventional jointed revenue service track, each rail must be bolted with at least 2 bolts at each joint. Yard track joints must be bolted with at least one bolt on each rail.

g) In CWR track, each rail must be bolted with at least 2 bolts at each joint used to connect CWR strings or to connect CWR to conventional rail.

h) When any of the conditions in f) or g) are not met, a speed restriction must be put in place until the condition is corrected.

i) Each joint bar must be held in position by track bolts sized appropriately for the rail drilling – 1" bolts in 1-1/16" holes and 7/8" bolts in 15/16" holes. Bolts must be tightened sufficiently to provide adequate support for abutting rail ends and to allow longitudinal movement of rails within the joint to accommodate expansion and contraction due to mechanical and thermal stresses.

j) No rail or joint bar having a torch cut hole should be used in revenue service track. If, under emergency circumstances, it becomes necessary to burn a bolt hole in rail or reconfigure a joint bar by torch cutting (slotted holes), speed over the track must be restricted to 10 mph and the rail and/or joint bar removed from track within 72 hours.

Appropriate speed restrictions for the conditions indicated in d), f) and g) are as follows: d) = 10 mph; for pull-aparts 2" or less associated with f) and g), the restriction shall be a maximum of 25 mph or less at the discretion of the Inspector (qualified under **LRT213.7**); for pull-aparts in excess of 2" associated with f) and g), the restriction shall be 10 mph and revenue service train operation only under the constant supervision of an individual designated under **LRT213.7**. Should the Inspector determine that the track is unsafe for passage of trains at any speed, the track should be taken out-of-service until repairs are made.

LRT213.122 Torch Cut Rail.

Except as a temporary repair in emergency situations, no rail having a torch cut end shall be permitted in revenue service track. When such a repair is necessary, speed over that track should be restricted to 10 mph and the torch cut rail removed from track within 24 hours. Torch cut rail in non-revenue service track should be inspected on a regular basis and removed from track within 30 days.

LRT213.123 Tie Plates.

Where timber crossties are used there shall be tie plates under the running rails on at least 9 out of any 10 consecutive ties.

LRT213.125 Rail Anchoring.

Longitudinal rail movement must be effectively controlled. Rail anchors (or elastic spring clip fasteners exerting a minimum nominal vertical force of 2000 lbs. each) must be applied to CWR track as outlined in **Appendix G**, Blue, Orange and Red Lines Track Standards.

In jointed track, effective rail anchoring is provided by spring clip anchors in "Pandrol" type track construction. In track-spike type track construction, the recommended application of anchors is 8 anchors per 39' rail to resist longitudinal movement in the normal direction of traffic. Sufficient "backup" anchors should be provided to protect against reverse running traffic, normal temperature effects in the reverse direction and excessive joint pull apart in the event of a broken rail or failed joint.

LRT213.127 Rail Fastening Systems.

Rails shall be fastened by a system of components which effectively maintains gage within the limits prescribed by **LRT213.53**. Crossties, the minimum number of which is stipulated under **LRT213.109**, must have effective rail fasteners on both the gage and field sides of both rails. There shall not be more than 2 consecutive ties which do not have effective rail fasteners on both sides of both rails.

Where elastic/resilient rail fasteners are used, they must meet the requirements for effective rail anchors *and* for effective track fasteners.

In slab track or in directly fixated track, at least 12 track fastener assemblies in curved track (<1500' R) and at least 9 track fastener assemblies on tangent track, in any 39' of track must have effective rail fasteners on both sides of both rails. There shall be no more than 2 consecutive track fastener assemblies which do not have effective rail fasteners on both sides of both rails.

LRT213.129 Rail Shims.

If track geometry is out of compliance with the requirements set forth under Part C herein and the working of ballast is not possible due to weather or other natural conditions, rail shims may be used to temporarily correct the deficiencies. The shims must be removed, track resurfaced and the ties tamped to a solid bearing as soon as weather permits.
Shims must be installed directly beneath the tie plates on top of the ties. Tie plates should never be removed from ties as a means of adjusting the surface or cross level of track. The proper length track spike shall be used with shims corresponding with the shim thickness (6" up to 1" shim, 8" over 1" up to 2" shim). Special considerations, including restricted speed, must be made for shims over 2".

Shimmed track must be inspected on a greater frequency than that required for regular track. Special attention must be given to the gage holding and surface maintaining capabilities of the shims.

LRT213.133 Turnouts and Track Crossings.

a) Fastenings in turnouts and track crossings must be kept tight and adjusted to keep track components securely in place and functional. All turnout components must be kept free of obstructions which might interfere with the passage of train wheels.

b) Rail anchors (or elastic spring clip fasteners) must be installed through turnouts and crossovers and on each side of track crossings, switches, frogs and guard rails to restrain movement of rails which may affect the position of switch points and/or frogs.

c) Flangeways through turnouts and track crossings must be a minimum of 1-1/4".

LRT213.135 Switches.

a) Stock rails must be properly and securely seated within switch plates. Care must be exercised not to overdrive adjustable rail braces which will unseat the rail base, affect gage and cant the rail.

b) Switch points must fit against stock rails properly with the switch thrown in either direction. Train wheels must be able to pass through switches without contacting the tip of switch points. Lateral and/or vertical movement of a stock rail within switch plates or of a switch plate on a tie must not adversely affect the fit of a point to a stock rail. Nor shall such movement adversely affect the locking capability of the switch machine. Prompt corrective action is required in such eventualities.

c) The heel of each switch point must be secure, loose bolts tightened and missing or broken bolts promptly replaced.

d) Unusually or excessively chipped/worn switch points should be repaired or replaced. Metal flow must be removed to ensure proper closure. Gage criteria at **LRT213.53** should be used to determine wear limits of switch points. Actual gage = static gage measurement including switch point sidewear, measured 1/4" below the top of point, plus any dynamic movement of track due to lateral loading.

LRT213.136 Switch Cover Guards and Guarded Switch Points.

Cover guards (sometimes called "housetops") and guarded, double switch points are designed to minimize wear to the curved, single switch points and to discourage wheel climb by a train making a turnout move. Cover guards are cast manganese steel while guarded, double switch points are rolled, heat-treated carbon steel.

1) Cover guards must be kept securely fastened to the chairs upon which they rest. Loose cover guard bolts should be tightened and missing or broken bolts replaced. Care must be taken to use the proper bolt length, bolts protruding more than minimally below the bottom of the cover guard may contact the switch point and prevent its proper throw.

2) Cover guard chairs must be kept securely fastened to the plates/ties upon which they sit. A "plow" bolt design of attaching the chair to plate has become the MBTA standard. It has replaced the previous designs in which 1) screw spikes fasten the chairs to plates and ties or 2) "through" bolts are used. Through bolts are connected to small bearing plates at the bottom of the tie. After a period of use, the older designs fail and the function of the cover guard is defeated. The cover guard lifts under the application of lateral loading imparted by train wheels and "rolls" away from the load.

Switches with older design cover guard systems should be retrofit with the "plow" bolt design.

c) The contact face of cover guards should be restored to its original configuration by welding when it has worn 1/4". Care should be exercised in ensuring that the contact face of the cover guard matches well in a vertical plane to the restraining face of the attached 132# restraining rail. The rail may need to be welded and ground to achieve this match. Any weld should be "run out" in a minimum of 6" to provide a smooth transition. The nominal flangeway width between cover guard and gage line of stock rail is 1-5/8" (except in special cases as outlined in **LRT213.53**).

d) Double switch points are comprised of a length of 132# restraining rail and a length of 115# running rail. Both rails are milled and planed and then bolted together. **The design switch throw for LRT switches is 3-1/2"**. This dimension is critical with respect to the restraining capability of the double switch point. The dimension should be regularly checked at each switch and adjusted as necessary.

e) Double switch points are braced against lateral loading by switch stops. These stops are connected to switch plates in the same fashion as cover guard chairs. The plow bolt design should be used whenever possible. The restraining ability of the double switch is reduced with wear to the 132# side of the point. The point should be replaced when the wear exceeds 1/4". Replacement of the double point is generally necessary every other time the single, curved point is replaced.

LRT213.137 Frogs.

a) All frogs in LRT track are flange-bearing. The flangeway depth of frogs, measured from a plane across the wheel-bearing area (straightedge on point and both wings), is designed to be 11/16". Refer to **LRT213.337** for maintenance limits for depth of grooves in the floor of flange-bearing frogs.

b) Any frog point chipped, broken or worn 5/8" deep from the plane measured in **LRT213.137** a) and within 6"of the tip of the frog point calls for a speed restriction of 6 mph max. over that frog.

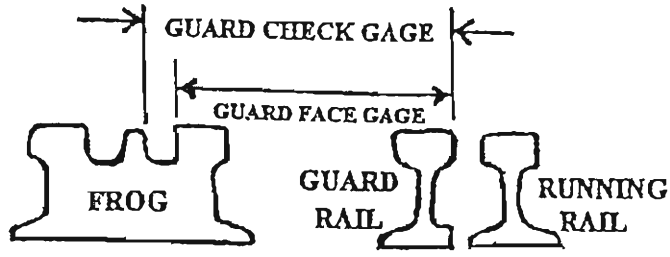
c) If the tread portion (wings) of a frog casting is worn down more than 3/8" below the original contour, operating speed over that frog is limited to 10 mph.

d) Grinding of "flowed metal" on frog points and wings at impact areas should be done *before* cracking occurs. This practice will prolong the life of frogs and help prevent breakouts. Battered frog points should be built up by welding *before* wings begin to show signs of batter.

e) Loose frog bolts should be tightened and missing/broken bolts replaced as a matter of routine maintenance. Frog fasteners should be maintained and plates should be checked during Switch Certification for signs of movement.

LRT213.143 Frog Guard Rails and Guard Faces; Gage.

The diagram below illustrates the "guard check gage" dimension at the point of frog. The guard check measurement is taken on a plane 5/8" below the *running* surface of the frog and of the *running* rail opposite the frog. The use of the standard Roadmaster gage will be ineffective within the flange bearing area due to the shallow depth of the flangeway. Measurements must be taken at the bottom of the flange bearing ramps where the flangeway is at least 1" deep.



GL Guard Check Gage	
Maintenance Threshold	**Response Action**
Green >55 3/8" - <55 5/8"	No action required.
Yellow 55 1/4" - 55 3/8"	Monitor, repair before Red condition is reached.
Red <55 1/4"	Restrict @ 5mph, repair immediately.

PART E – TRACK APPLIANCES

LRT213.201 Scope.

This part prescribes minimum requirements for certain track appliances.

LRT213.204 WEZE (Impedance) Bonds and Cable Leads.

In the course of routine track inspection, it is important that the condition of WEZE bonds and the associated cable connections to the running rails are checked.

Although the bonds are the responsibility of the Signal Division, damage from hanging train equipment or track maintenance should be brought to the attention of supervisory personnel. Special attention should be given to the cable leads. If the insulation on the cables is damaged or the cable appears to be crushed or broken, it should be noted. Most importantly, cable connections to the running rail web should be inspected. The Cadwelded connection at this location is a common site of rail defects which typically develop internally. As such, they are not detectable by eye. However, often the defects develop into cracks in the web which, if not detected, can become broken rails. Generally the break happens suddenly when

the rail is subjected to a concentrated impact load such as from a flat wheel. Any unusual condition should be brought to the attention of supervisory personnel. The location of disconnected leads should be noted on the track inspection report.

LRT213.205 Derails.

Each derail in LRT track must be kept clearly visible at all times, must be locked when not in use and must be maintained to prevent it from being operated without removing the lock. Derails found unlocked must be reported to the GL Dispatcher immediately.

PART F – INSPECTION

LRT213.231 Scope.

This section prescribes MBTA requirements for the frequency and nature of LRT track inspection. Track inspection at the MBTA is regulated by the Commonwealth of Massachusetts' Department of Telecommunications and Energy. DTE regulations can be found in Appendix F.

LRT213.233 Track Inspections.

1) **Frequency:**
a) All LRT track must be inspected a minimum of three times per week, yard track included, with at least one calendar day interval between inspections.

b) Any LRT track undergoing or awaiting repair upon which a speed restriction is assigned shall be inspected at a frequency which will ensure safe operations at all times.

c) Each switch, turnout and track crossing must be inspected on foot at least monthly. In the case of track which is used less than once a month, each switch, turnout and track crossing must be inspected before it is used.

d) In the event of fire, flood, severe storm or other occurrence which might have damaged the track structure, a special inspection must be made of the track involved as soon as possible after the occurrence.

e) The DTE may require inspections at more frequent intervals in areas of dense traffic, high operating speeds or questionable physical conditions.

2) Qualifications: the MBTA shall designate qualified persons to inspect track for defects. Each person so designated must have:

A) Experience/Education –
a) At least one year experience in track inspection, or
b) A combination of experience in track inspection and training from a course in track inspection or from a college level educational program related to track inspection.

B) Ability to –
a) Understand inspection requirements;
b) Detect deviations from the inspection requirements;
c) Prescribe appropriate remedial action to correct or safely compensate for deviations; and
d) Procure written authorization from the MBTA to prescribe remedial actions to correct or safely compensate for any deviations from the inspection requirements pending review by a qualified person designated under DTE regulations 220 C.M.R. 151.08(4)(a).

3) **Inspections:** each inspection must be made on foot or riding over the track in a vehicle at a speed that allows the person making the inspection to visually inspect the track structure for compliance with the DTE regulations and the Standards set forth herein. Mechanical, electrical and other track inspection devices may be used to supplement visual inspection. If a vehicle is used for visual inspection, the speed of the vehicle may not be more than 5 mph when passing over grade crossings or special trackwork.

LRT213.235 Switch Certification.

In addition to the inspection schedule outlined in **LRT213.233**(1), all turnouts at the MBTA are subject to inspection under the System Certification process. This process directs that all revenue service turnouts are thoroughly inspected on an every other month basis. Non-revenue turnouts are subject to System Certification inspection on a quarterly basis. During the System Certification inspection, a series of specific measurements is taken and recorded to ensure that the turnout is in compliance with the Standards. Records of System Certification are maintained at Line headquarters.

LRT213.237 Inspection of Rail.

In addition to the inspection schedule outlined in **LRT213.233**(1), at least once a year a continuous search for internal rail defects (ultrasonic and/or induction testing) must be made of all rail in all track with operating speeds of 40 mph or greater.

Inspection equipment must be capable of detecting defects between the joint bars in the area of the rail enclosed by joint bars.

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

LRT213.241 Inspection Records.

A written record of each track and/or rail inspection required to be performed shall be kept on file. The MBTA is required by the DTE to designate a location where each original record shall be maintained for at least one year after the date of the inspection. Original records must be retained for at least two years after the date of the inspection and for one additional year after remedial action is taken. Complete details of inspection requirements can be found in the DTE regulations under Section 151.08(5)

LRT213.243 Duties and Responsibilities of Supervisors, Section Foremen and System Repairpersons.

The organizational reporting structure of the M.O.W. Division is as shown below:

Superintendent M.O.W.
↑
M.O.W. Line Supervisor
↑
Section Foreman
↑
System Repairman

The *Superintendent M.O.W.* oversees the activities of a Supervisor or Supervisors. The Superintendent is responsible for planning and policy making decisions.

The *M.O.W. Line Supervisor* generally is assigned to one of the four transit lines (Blue, Orange, Red or Green) and is responsible for all track/M.O.W. related issues on that line. From an inspectional standpoint, the Supv. monitors and maintains records of daily, monthly and bi-annual track and turnout inspections. The Supervisor must personally inspect every turnout and special trackwork location in his/her territory twice a year. Records of these inspections shall be maintained under **T213.241 and/or LRT213.241.**

Section Foremen are assigned a territory for which they assume responsibility for the activities of all System Repairmen (track inspectors) in that territory. The System Certification process is the direct responsibility of the Section Foreman. The Section Foreman must ensure that all track inspection and System Certification documentation is correctly completed in a timely fashion. The Section Foreman is responsible for bringing to the attention of the Line Supervisor track deficiencies noted on daily inspectional reports or discovered by him/her during System Certification.

System Repairpersons or Track Inspectors are the individuals who perform vital inspectional functions on a daily basis. System Repairpersons should not just walk track, but must be able to recognize exceptions to the Track Maintenance Standards. System Repairpersons are responsible for daily track inspection forms and must communicate any abnormalities or exceptions to the Track Maintenance Standards to their Section Foreman and/or Supervisor. System Repairpersons must be qualified per DTE regulations under Section 151.08(4)(b).

LRT213.245 Ancillary Responsibilities.

All employees, while on track, must be aware of and report any potentially dangerous or hazardous condition. Examples of such conditions are: fallen or loose materials from structures or buildings, downed or damaged R.O.W. fencing, washouts, catenary problems, graffiti, damaged or obstructed wayside signals or signs, etc.

Any condition, which in the estimation of an individual qualified under **LRT213.7**, could cause damage to a train, its occupants or other personnel on track, must be addressed immediately. Response includes notification of the Green Line Dispatcher, the Maintenance Control Center and a Green Line M.O.W. supervisory person. The individual discovering the problem must remain on scene directing trains past the problem (if passage is possible) until relieved or until the problem is corrected.

PART G – GIRDER RAIL TRACKWORK

LRT213.331 Scope.

This part prescribes recommended maintenance guidelines and maintenance threshold limits for girder rail trackwork.

LRT213.334 Track in Pavement.

Inspection of paved track, with the exception of the running surface of the rail, cannot be performed because the track structure is embedded in asphalt or concrete pavement. Track inspectors should take note of any signs of lateral or vertical movement of the rails which is evidence of underlying problems. Rail movement is detectable through failure of the paving material adjacent to the rails and is indicative of subsurface track structure deterioration.

LRT213.337 Girder Rail Special Trackwork – Maintenance Threshold Limits.

This part identifies maintenance threshold limits for tongue switch, point mate and frog components. The limits shown in the following tables apply to specific conditions which exist in isolation for the component listed. Combinations of marginally defective conditions must be evaluated collectively.

Special attention needs to be given to YELLOW coded track conditions. Such conditions, technically qualifying as track defects but not necessarily requiring immediate attention, could contribute to train derailment or component failure when combined with other marginal track conditions, operator error and/or vehicle malfunction. Particular notice should be taken, especially when evaluating tongue switch

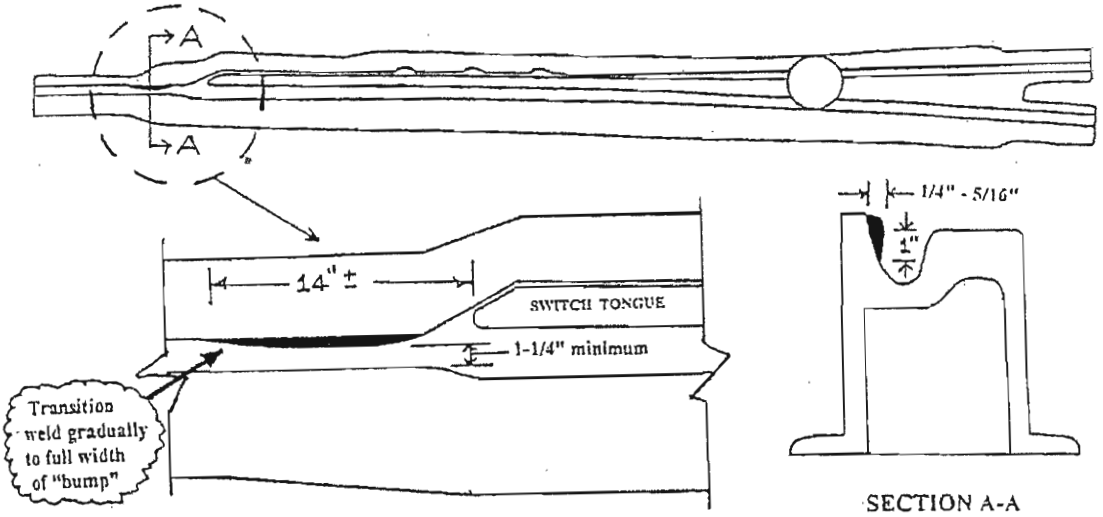
condition, of track surface and crosslevel conditions in the immediate vicinity of the switch. Slightly abnormal weight distribution of a light rail vehicle due to marginally imperfect vertical track alignment, in combination with a YELLOW coded tongue switch anomaly, for example, can contribute to derailment cause. Refer to **LRT213.4** for further details.

LRT213.337 – Girder Rail Special Trackwork -- Maintenance Threshold Limits

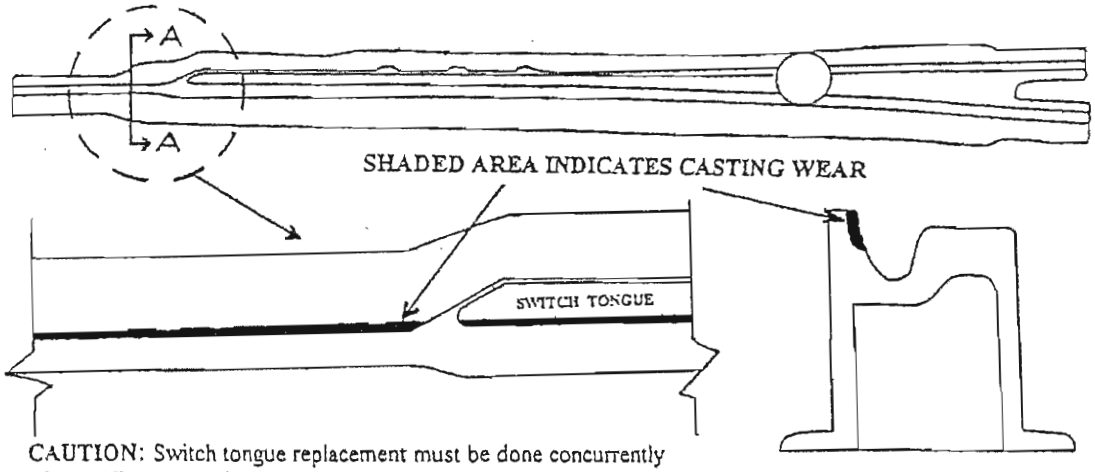
Component		Tongue Switch Casting	Switch Tongue
Defect Description		Corrosion, broken/ missing plate, fastener failure, hanging tie, etc.	Loss of rounded edge at restraining face corner
Effect on Component		Lateral - vertical movement	Increased wheel climb potential
Measurement Parameter		Amount of deflection	This condition only applies to new casting or tongue installations until the restraining face angle has worn to five degrees or greater. Until restraining face wear has developed, "touch-up" sharp edge at restraining face corner with straight grinder. Exercise care as to not remove any more steel than is necessary to relieve sharp edge and discourage wheel climb on tongue.
Maintenance Limits	Green	1/4"	
	Yellow	1/2"	
	Red	3/4"	
Response Action	Green	Monitor condition	
	Yellow	Repair within 14 days	
	Red	Repair within 48 hours	

LRT213.337 -- Girder Rail Special Trackwork – Maintenance Threshold Limits

Component		Tongue Switch	Tongue Switch
Defect Description		Worn casting restraining face weld *	Worn casting restraining face ahead of tongue **
Effect on Component		Increased wheel-to-tongue "angle of attack"	Increased wheel climb potential
Measurement Parameter		Original weld profile	Original casting profile
Maintenance Limits	Green	1/8"	1/8"
	Yellow	3/16"	1/4"
	Red	1/4"	1/2"
Response Action	Green	Monitor- note on report.	Monitor- note on report.
	Yellow	Schedule repair before red limit is reached.	Schedule repair before red limit is reached.
	Red	Restrict vs. turnout moves, Re-weld within 24 hrs	Restrict vs. turnout moves. Weld within 24 hrs.
		**** Only applies where weld has been added to casting restraining face. (Refer to sketch on following page for details of weld)***	***** Switch tongue must be replaced in conjunction with weld repair of restraining face over 1/8". (Refer to next page for details)***



SECTION A-A

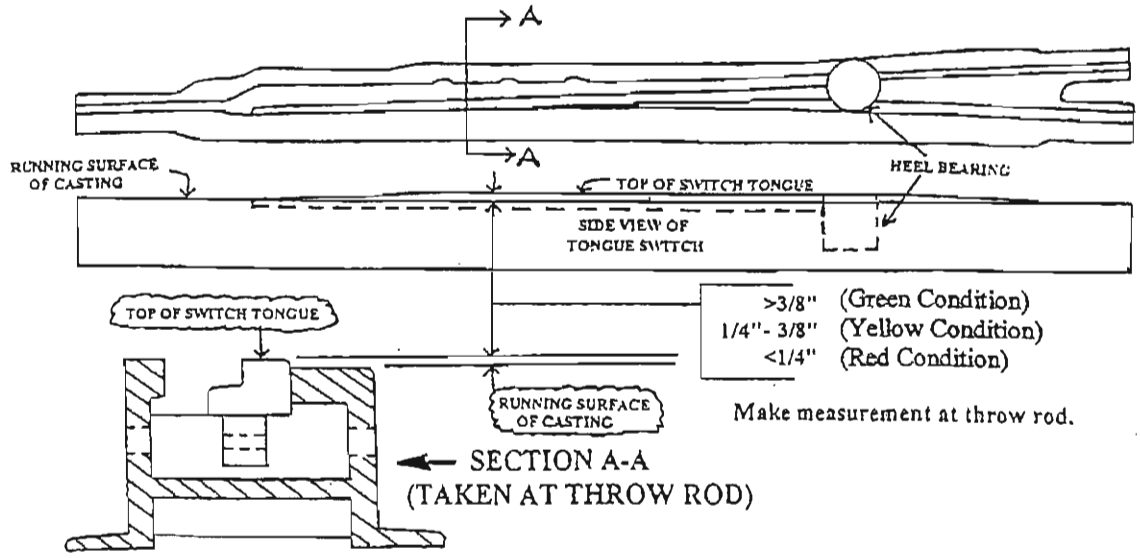


CAUTION: Switch tongue replacement must be done concurrently with welding restoration of casting restraining face when casting wear exceeds 1/8". Failure to do so will result in increased wheel climb potential.

SECTION A-A

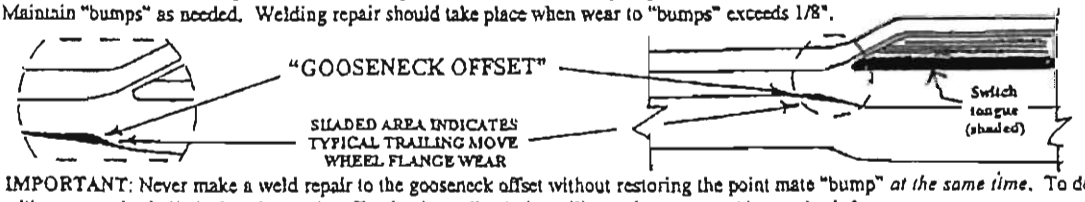
LRT213.337 -- Girder Rail Special Trackwork –Maintenance Threshold Limits

Component		Tongue Switch	
Defect Description		Tread-worn (straight moves)	
Effect on Component		Loss of lateral wheel restraint - increased climb potential	
Measurement Parameter		Top of tongue to top of cast- casting body running surface. Measure at throw rod.	
Maintenance Limits	Green	>3/8"	
	Yellow	1/4" to 3/8"	
	Red	<1/4"	
Response Action	Green	----	***Repair by grinding casting body running surface or by replacing tongue to achieve minimum of 3/8" restraint at throw rod as indicated in sketch below.***
	Yellow	Schedule repair before red limit is reached.	
	Red	Restrict against turnout moves. Repair within 24 hours.	

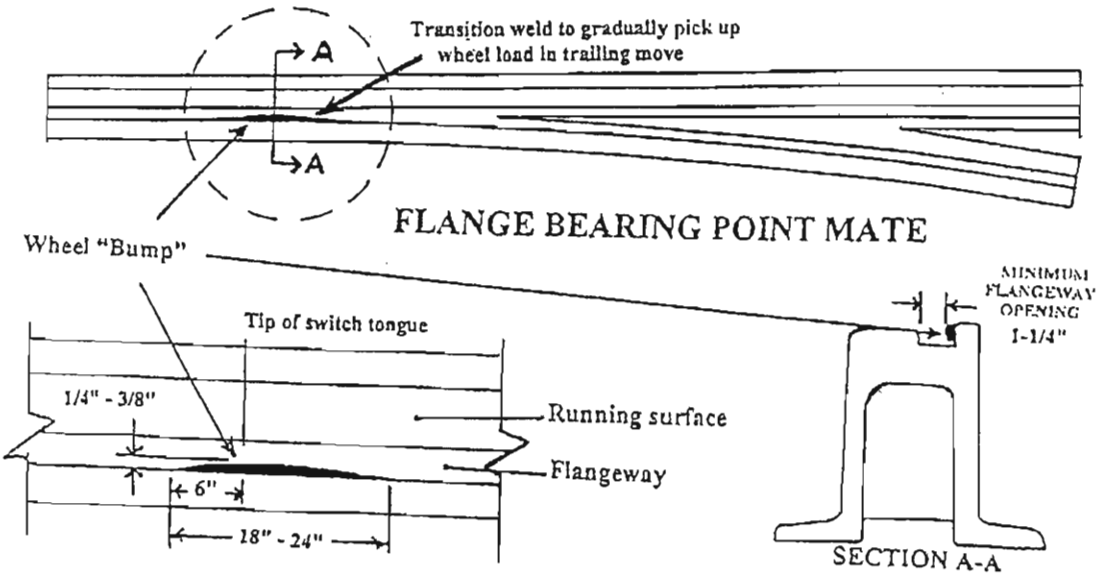


POINT MATE WELDED "BUMPS"

Use welded "bump" on point mates as indicated by details on following page. "Bumps" typically are only needed in switches 75' radius or less where required to prevent wheel of trailing axle of each truck during trailing move through switch from "clipping" gooseneck offset of tongue switch casting as shown below. Install "bumps" when wheel flange contact of tongue switch gooseneck offset is present in switches which are gaged in accordance with the criteria given in LRT213.339. Size (thickness) of "bumps" will vary according to switch manufacturer and radius. Test trains with typical wheel sets and wear should be used during "bump" installation to optimize performance of weld. "Bumps" should be no larger than what is minimally required to avoid tongue switch gooseneck offset wear. Maintain "bumps" as needed. Welding repair should take place when wear to "bumps" exceeds 1/8".

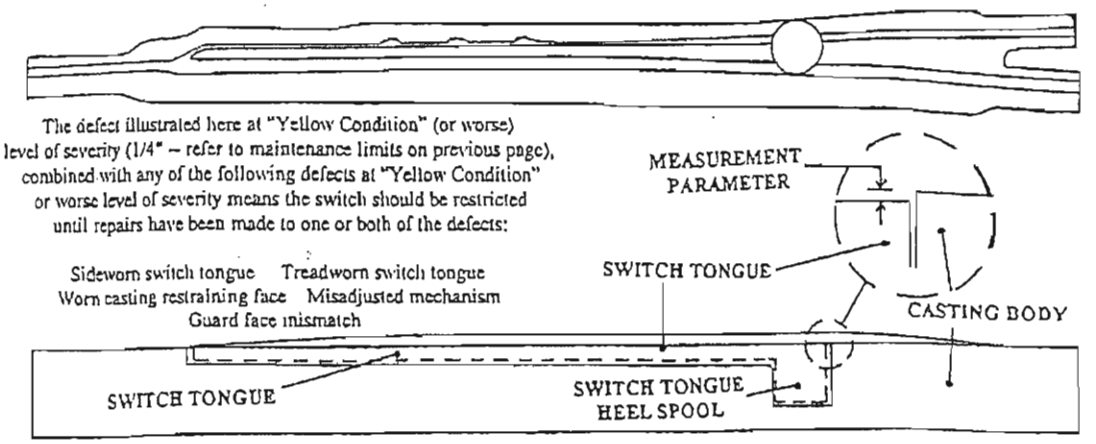


IMPORTANT: Never make a weld repair to the gooseneck offset without restoring the point mate "bump" *at the same time*. To do so will create a wheel climb situation at the offset by the trail axle in trailing point moves. Always check for proper gage.



LRT213.337 -- Girder Rail Special Trackwork Maintenance Threshold Limits

Component		Switch Tongue	*Refer to sketch and table on following page for illustration of condition and defect severity threshold at which switch must be restricted.*
Defect Description		Bottom of heel spool worn and/or floor of casting cavity worn	
Effect on Component		Tongue rocks in casting body under load	
Measurement Parameter		Running surface of tongue on spool to adjacent casting body running surface	
Maintenance Limits	Green	1/8"	
	Yellow	1/4"	
	Red	3/8"	
Response Action	Green	Monitor- note on report.	
	Yellow	Schedule for welding.	
	Red	Repair within 72 hours. Restrict if combined with other yellow level defects as indicated.	



LRT213.337 -- Girder Rail Special Trackwork Maintenance Threshold Limits – Page 54

Component		Switch Mechanism	Tongue Switch
Defect Description		Worn, damaged or missing parts	Loose, bent, stripped threads
Effect on Component		Lack of proper switch performance. (Poor spring tension)	Sloppy switch performance; inability to throw switch.
Measurement Parameter		Tongue to casting body relationship.	Tongue to casting body relationship.
Maintenance Limits	Green	-----	-----
	Yellow	1/8"	1/8"
	Red	1/4"	1/4"
Response Action	Green	-----	-----
	Yellow	Adjust within 48 hours.	Repair within 24 hours. Restrict switch at 3 mph
	Red	Repair immediately. Supervise all trains through switch.	Repair immediately. Supervise all trains through switch.

LRT213.337 -- Girder Rail Special Trackwork Maintenance Threshold Limits

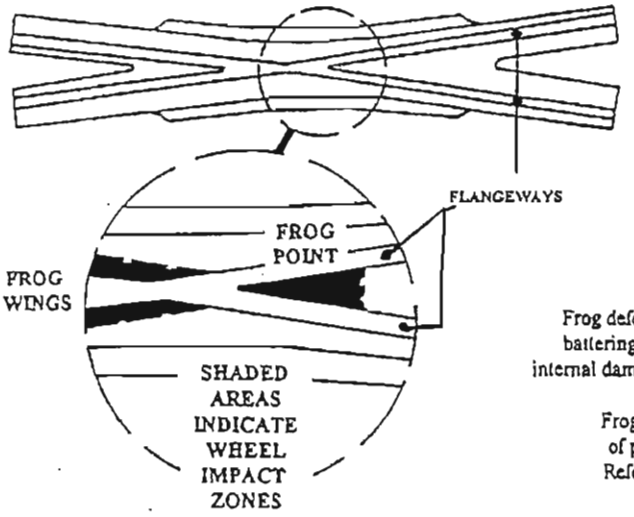
Component		Point Mate and/or flange- bearing frogs	Girder Rail				
Defect Description		Grooves in casting floor	Sidewear (gage corner) and tread wear (running surface)				
Effect on Component		Possible misdirection of train wheels – may contribute to wheel climb in combination with other factors.	Loss of rail head and gage widening (from sidewear)				
Measurement Parameter		Depth of grooves in flange-bearing area of casting floor	Original rail profile (Note: gage measurement – 5/8" down)				
Maintenance Limits	Green	1/8"	Sidewear*	1/4"	Tread wear	1/4"	*Limited by gage maintenance criteria at LRT213.339
	Yellow	1/4"		3/8"		3/8"	
	Red	>1/4"		5/8"		1/2"	
Response Action	Green	Monitor		Monitor			
	Yellow	Schedule for welding within 7 days.		Schedule rail change before red limit is reached.			
	Red	Repair within 72 hours.		Rail is condemnable Remove from track.			

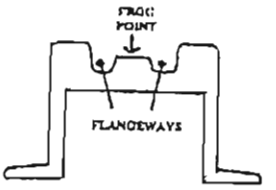
LRT213.337 -- Girder Rail Special Trackwork Maintenance Threshold Limits

Component		Girder Rail (also any connections to castings)	Girder Rail (also any connections)			
Defect Description		Vertical rail end mismatch	Guard face mismatch			
Effect on Component		Wheel and rail batter	Potential of wheel climb			
Measurement Parameter		Extent of wear relative to original rail profile	Actual mismatch			
Maintenance Limits	Green	1/8"	1/8"	** Tangent track **	1/16"	** Curved track **
	Yellow	3/16"	1/4"		1/8"	
	Red	1/4"	>1/4"		>1/8"	
Response Action	Green	Monitor	Monitor		Monitor	
	Yellow	Restrict speed to 10 mph. Repair within 7 days.	Restrict 10 mph. Repair within 14 days.		Restrict 10 mph . Repair within 48 hours.	
	Red	Restrict speed to 5 mph and repair within 24 hours	Restrict 5 mph. Repair within 72 hours..		Restrict 5 mph. Repair immediately.	

LRT213.337 -- Girder Rail Special Trackwork Maintenance Threshold Limits

Component		Frog	Frog	*Refer to sketches on following page for frog illustration.*
Defect Description		Battered, worn or otherwise damaged point	Breakout – Piece(s) of steel detached from frog point	
Effect on Component		Higher than normal wheel impact, damage to frog casting	Life of casting cut short – Derailment risk increased	
Measurement Parameter		Extent of wear from original frog point profile	Size and location of breakout relative to frog point	
Maintenance Limits	Green	1/8"	Green – surface cracking Yellow – chipping of frog point or flangeway walls Red – chipped back 6" or 3/8" deep	
	Yellow	1/4"		
	Red	3/8"		
Response Action	Green	Monitor, note in report.	Green – monitor progress of defect of defect and note in report Yellow – schedule for welding or replacement Red – restrict speed to 6 mph and repair or replace within 24 hrs.	
	Yellow	Schedule for repair before red limit is reached.		
	Red	Repair or replace within 72 hours.		





SECTION THROUGH
POINT OF FROG

FROG DEFECTS

Frog defects come in the form of wear to the point and wings; battering of the point and wings leading to surface cracks and internal damage; and lipping of the gage corners into the flangeways.

Frog defects also include "break outs" or detachment of pieces of the casting steel in the point and wings. Refer to the previous page for maintenance threshold limits governing all conditions.

LRT213.339 Girder Rail Gages and Flangeways.

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Minimum gage for conventional girder rail track is 56-3/16" for tangent alignment, 56-3/8" in curves 100'R to 1000'R and 56-3/4" in curves <100'R. See Pages 40 and 41 for special trackwork criteria.

****

MAXIMUM TRACK GAGE LIMITS FOR CONVENTIONAL GIRDER RAIL TRACK (SEE LIMITS FOR SPECIAL TRACKWORK ON PAGES 40 and 41)				
For 149 RE7A Section Girder Guard (Flangeway = 1-3/4"):				
Track Configuration.	Design Gage	Maintenance Threshold Limits Response Actions		
		Green	Yellow	Red
Tangent	56-1/2"	57"	57-1/8"	57-1/4"
Curves >1000'R	56-1/2"	57-1/8" Monitor – Note on inspection report.	57-1/4" Restrict speed to 25 mph max. Repair within 72 hours.	57-3/8" Restrict speed to 10 mph max. Repair within 24 hours.
Curves 100'R -1000'R (149# rail both in & out)	57"	57-1/4" Monitor – Note on inspection report.	57-1/2" Restrict speed to 15 mph max. Repair within 72 hours.	57-3/4" Restrict speed to 5 mph max. Repair within 24 hours.
Curves 100' R-1000' R (149# in- side, 115 or 128# outside)	56-7/8"	57-1/8"	57-3/8"	57-5/8"
		Same response actions as for curves with 149# both inner and outer rails.		
Curves less than 100'R	57-1/8"	57-1/4" Monitor – Note on inspection report.	57-1/2" Restrict speed to 5 mph max. Repair within 24 hours.	>57-5/8" Supervise all train moves over track until repaired.

MAXIMUM TRACK GAGE LIMITS FOR CONVENTIONAL GIRDER RAIL TRACK (SEE LIMITS FOR SPECIAL TRACKWORK ON PAGES 40)				
For 118 GGR Section Girder Guard (Flangeway = 1-1/2"):				
Track Configuration	Design Gage	**Maintenance Threshold Limits Response Actions**		
		Green	**Yellow**	**Red**
Tangent	56-1/2"	57"	57-1/8"	57-1/4"
Curves >1000'R	56-1/2"	57-1/8" Monitor – Note on inspection report.	57-1/4" Restrict speed to 25 mph max. Repair within 72 hours.	57-3/8" Restrict speed to 10 mph max. Repair within 24 hrs.
Curves 100'R - 1000'R (GGR 118 both rails)	56-3/4"	57" Monitor – Note on inspection report.	57-1/4" Restrict speed to 15 mph max. Repair within 72 hours.	57-1/2" Restrict speed to 5 mph max. Repair within 24 hours.
Curves 100'R - 1000'R (118 inside, 115 outside)	56-7/8"	57-1/8"	57-3/8"	57-5/8"
		Same response actions as for curves with GGR 118 both inner and outer rails.		
Curves less than 100'R	57"	57-1/4" Monitor – Note on inspection report.	57-1/2" Restrict speed to 5 mph max. Repair within24 hours.	57-3/4" Supervise all train moves over track until repaired.

GAGE AND FLANGEWAY CRITERIA FOR 149# AND 118# GIRDER RAIL SPECIAL TRACKWORK

Within turnouts of all radii:

Rail Type	Track Location	Design Gage	Min. Gage	Maximum Gage Limits		
				Green	Yellow	Red
149 118	Entering Switch	56-5/8"	56-3/8"	56-3/4"	56-7/8"	>57"
149	Leaving Switch	57" cvd. 56-3/4" str.	56-3/4" 56-1/4"	57-1/8" 57"	57-1/4" 57-1/4"	57-3/8" 57-3/8"
118	Leaving Switch	56-3/4" cvd. 56-5/8" str.	56-5/8" 56-1/4"	57" 57"	57-1/4" 57-1/4"	57-3/8" 57-3/8"
149	Opposite Frog point	57-1/4" cvd. 56-7/8" str.	57-1/8" 56-5/8"	57-3/8" 57-1/8"	57-1/2" 57-1/4"	57-5/8" 57-1/2"
118	Opposite Frog point	56-3/4" cvd. 56-5/8" str.	56-5/8" 56-1/4"	57" 57"	57-1/4" 57-1/4"	57-3/8" 57-3/8"

Within Diamond crossings:

Rail Type	Track Location	Gage Design	Min. Gage	Maximum Gage Limits		
				Green	Yellow	Red
149	Through frog castings	56-3/4" cvd. 56-1/2" str.	56-1/2" 56-1/4"	56-7/8" 56-3/4"	57-1/8" 57"	57-3/8" 57-1/4"
149	Every-where else	57" cvd. 56-1/2" str.	56-3/4" 56-1/4"	57-1/4" 56-3/4"	57-1/2" 57"	57-5/8" 57-1/4"
118	Throughout crossing	56-3/4" cvd. 56-1/2" str.	56-1/2" 56-1/4"	56-7/8" 56-3/4"	57-1/8" 57"	57-3/8" 57-1/4"

Response Actions for color-coded maintenance threshold exceptions in girder rail special trackwork:

Green: monitor conditions – make note of exception on track inspection report.

Yellow: restrict speed through switch or crossing to 10 mph (for radii over 100') or 5 mph (for radii 100' or less); schedule repairs to be done within 72 hours.

Red: supervise all train moves through switch or crossing until remedial measures have been taken.

Flangeway Design Criteria for Girder Rail Special Trackwork
Through diamond crossings (within frog castings) for both 149# and 118# rail: Curved road – 1-1/2" inner and outer Straight road– 1-3/8" both sides
Through 149# switches: Curved road – 1-3/4" inner and outer Straight road– 1-3/4" both sides
Through 118 # switches: Curved road – 1-1/2" inner and outer Straight road– 1-1/2" both sides
Flangeway maintenance threshold limits for both diamond crossings and turnouts are governed by Guard Check and Guard Face criteria at **LRT213.143**. Actual flangeway width of 149# rail is 1-7/8" and of 118# rail is 1-5/8". Due to configuration of gage corners and faces of restraining (or guard) components, flangeway widths are represented as 1-3/4" for 149# rail and 1-1/2" for 118# rail for the purposes of establishing maintenance criteria.

Appendix A

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SYSTEMWIDE MAINTENANCE AND IMPROVEMENTS

SPECIAL ORDER #98-2

(Revised 8-31-98)

TO: All Maintenance of Way Personnel

RE: Procedure for Instituting Speed Restrictions

The following procedure will be in effect immediately for the institution of speed restrictions related to abnormal track conditions:

The individual in whose name the speed restriction will be posted shall contact the Maintenance Control Center at 222-5278. The specified location of the restriction, reason for the restriction and reduced speed of the restriction must be clearly communicated to the Maintenance Control Center. This information must be logged by the MCC.

The individual placing the restriction must contact the OCC Dispatcher and communicate the same information which was given to the MCC. OCC phone numbers are 222-5707 for the Red Line, 222-5842 for the Green Line, 222-5744 for the Orange Line and 222-5774 for the Blue Line. The OCC Dispatcher will log the information and make radio broadcasts to advise operating personnel of the restriction.

The individual placing the restriction must arrange for the placement of speed signs and resume signs at appropriate locations. THIS MUST BE DONE AS SOON AS PRACTICALLY POSSIBLE AFTER THE RESTRICTION HAS BEEN INSTITUTED. Both the MCC and the OCC Dispatcher shall be notified when the required signs are in place.

UNTIL THE REQUIRED SIGNS HAVE BEEN POSTED IN THE FIELD OR THE APPROPRIATE ATO CODE HAS BEEN SET BY SIGNAL DIV. PERSONNEL, THE INDIVIDUAL PLACING THE RESTRICTION MUST REMAIN AT THE SITE OF THE RESTRICTION UNTIL A TRANSPORTATION OFFICIAL IS DISPATCHED TO THE LOCATION. AN OFFICIAL WILL REMAIN AT THE LOCATION UNTIL THE AFOREMENTIONED REQUIREMENTS ARE MET.

Tom Taylor - Director of Systemwide
Maintenance and Improvements
AUGUST 31, 1998

Appendix
B

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SUBWAY OPERATIONS/
M.O.W. DIVISION

RESTRICTED OPERATION
NOTIFICATION

DATE:

LINE:

LOCATION:

RESTRICTION:

ESTIMATED DURATION:

COMMENTS:

***OCC Dispatcher Phone Nos.: Green Line 5842 – Red Line 5707 – Orange Line 5744 – Blue Line 5774

***OCC/MCC Fax No.: 6192

Appendix F

Track Defect Codes

LRT MAINTENANCE STANDARDS

****

LRT213.33 – Drainage
Blocked, obstructed

LRT213.37 – Vegetation
Overgrown, dead, fallen

LRT213.53 – Gage
Wide, tight

LRT213.54 – Flangeway
Wide, narrow, blocked

LRT213.55 – Horizontal Track Alignment
Inconsistent, kinked,
line sweep, wavy

LRT213.63 – Track Surface (Vertical Track Alignment)
Dip, hump, "roller coaster", uneven SE, twist/warp

LRT213.65 – Clearances
Encroachment, evidence of contact

LRT213.103 – Ballast
Insufficient, fouled, low cribs, lack of shoulder

LRT213.109 – Crossties
Defective (reason), violation of which parameter

LRT213.113 – Defective Rails
Specify defect type and size

LRT213.114 – Rail Wear
Vertical (head wear), horizontal (gage wear)

LRT213.115 – Rail End Mismatch Gage side, running surface

LRT213.116 – Restraining Rail Bolt breakage, missing parts, rail wear, rail corrosion, rest. rail joint problems

LRT213.119 – CWR
Signs of instability (line waves, ballast pockets at tie ends, lack of proper anchoring

LRT213.121 – Rail Joints
Missing/broken bolts, loose bolts ("spinners"), cracked bars

LRT213.122 – Torch Cut Rail
Identify location

LRT213.123 – Tie Plates
Broken, missing, wrong size, corroded

LRT213.125 – Rail Anchoring
Insufficient, improperly applied

LRT213.127 – Rail Fastening Systems
Broken/missing clips, defective shoulders or inserts, loose, corroded or defective "eggs", creeping rail/damaged rail pads

LRT213.133 – Turnouts and Track Crossings
Loose bolts, missing anchors, obstructed or over-worn flangeways

LRT213.135 – Switches
Unseated stock rails, loose or missing adjust-able rail braces, poor switch point lay-up, worn or chipped points, excessive movement of point(s) stock rail(s) under load, hanging switch ties, loose or missing heel bolts

LRT213.136 – Switch Cover Guards and Guarded Points
Loose or missing cover guard bolts, loose or broken cover guard "chairs", worn cover guard face, poor double point lay-up, worn or chipped double point, ineffective double point "stops"

LRT213.137 – Frogs
Flangeway(s) obstructed by "plastic flow" from frog running surfaces, chipped or worn (use table on page 30), loose, broken or missing frog bolts, plate movement or breakage

LRT213.143 – Frog Guard Rails; Guard Check and Guard Face Gage
Violation of maintenance limits (see page 31)

LRT213.204 – WEZE Bonds and Cables
Damaged bond, broken or frayed cables, broken cable connections (welds) to running rails

LRT213.205 – Derails
Broken or damaged

LRT213.245 – Ancillary Responsibilities
Report any condition which may cause damage to trains, disrupt train movement, endanger personnel, compromise safety in any way or otherwise act as an obstacle to the delivery of a safe, reliable service.

Examples of such conditions are:

* Loose or spalling concrete from tunnel walls or roofs or from overhead bridges and structures

* Tunnel or station lighting failure

* Damaged right-of-way fencing

* Washouts involving tracks or adjacent areas

* Overhead catenary, cable or support problems

* Damaged signs or signals

* Evidence of structural damage to station platforms, concrete tunnel inverts, floating slabs, direct fixation slabs, retaining walls, etc.

* Damage to MBTA personnel walkways anywhere, especially on bridges and in tunnels. Damage to railings or tunnel ladders

* Grease or other chemical spills

LRT213.334 – Track in Pavement
Failure of paving material adjacent to rails

LRT213.337 – Girder Rail Special Trackwork
Refer to Defect Descriptions, Maintenance Limits and Response Actions on pages 39 through 54.

LRT213.339 – Girder Rail Gages and Flangeways
Refer to criteria on pages 55 through 58 for gage and flangeway maintenance threshold limits;

LRT213.116 for flangeway maintenance threshold limits in conventional tee rail track.

Appendix G

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MBTA Maintenance of Way Division

CWR INSTALLATION GUIDE
AND
TRACK BUCKLING COUNTERMEASURES

This information is provided to aid in the proper installation of continuous welded rail (CWR) and to help prevent the problems associated with missinstallation. It also is intended to supply information needed to maintain CWR to avoid track buckling/heat kink/sun kink related incidents. This guide is to be used in concert with the Maintenance of Way Division's Heavy and Light Rail Transit Track Maintenance and Safety Standards.

A. CONTINUOUS WELDED RAIL (CWR).

a. Continuous welded rail is designated by the initials "CWR" in this guide. Track constructed with "CWR" is referred to as "CWR track".

b. CWR must be installed and adjusted in accordance with the instructions given herein. After installation, it should not be raised or otherwise disturbed at rail temperatures higher than its installation or adjusted (de-stressed) rail temperature, except as noted herein.

The prevention of track buckling depends on the knowledge of the causes of buckling and the knowledge of safe temperature values and on the ability to detect buckling conditions.

NEUTRAL RAIL TEMPERATURE

a. By its nature, rail steel expands and contracts with temperature changes. Neutral rail temperature is that temperature range in which the longitudinal thermal stresses inherent in CWR strings because of expansion and contraction are reduced to a controllable level. Neutral rail temperature is considered to be between 90 and 110 degrees Fahrenheit.

b. All CWR greater than 78' in length should be installed at neutral rail temperature whenever it is practically possible. Time or weather constraints may preclude installation of CWR in the approved temperature range. In these cases the CWR must be adjusted (de-stressed) at the earliest opportunity before any significant change in temperature is anticipated. For if whatever reason the adjustment cannot be done before a significant change in temperature, *especially if temperatures will be significantly above the installed CWR temperature*, the speed over the track should be restricted to 10 mph until adjustment can be done.

c. Ideally, CWR should be installed at a temperature between 90 and 110 degrees. When ambient temperatures are below 90 degrees, the rail must be expanded to a length which will produce an equivalent neutral rail temperature over the entire length of the CWR string. This should be done through the use of an approved heating device. The required expansion must be calculated, executed and recorded. To ensure uniform expansion the rail should be vibrated to prevent binding within the tie plates or shoulders.

d. The Line Supervisor shall be responsible for recording the rail temperature for which CWR is anchored. The form included in these instructions should be used for that purpose. Copies of the forms shall be kept on record at the appropriate line headquarters.

B. ADJUSTMENT OF CWR OUTSIDE OF NEUTRAL RAIL TEMPERATURE RANGE.

a. To adjust CWR when its installation temperature was less than neutral rail temperature, its length must be decreased. For adjustment when the installation temperature was greater than neutral rail temperature, its length must be increased.

b. The length which CWR should be decreased or increased to adjust its length for a temperature higher or lower than its installation temperature may be calculated by using the following formula: L = T x CWR x 0.000078
L = length in inches of the adjustment required
T = difference between installation and neutral rail temperatures in degrees Fahrenheit
CWR = length of CWR string in feet
For example: to adjust the length of a 1200' CWR string installed at 40 degrees to fall within the neutral temperature range, subtract 40 from 100 produces a difference of 60 degrees and multiply as follows: 60 x 1200 x 0.000078 = 5.6 inches.
This means the 1200' CWR string must be adjusted be removing 5-1/2" of rail, heating to the neutral rail temperature range, re-anchoring the string and connecting either by welding or bolting to the adjacent string or rail.

c. For practical purposes and to eliminate the need to calculate the string length adjustment, the following table may be used for selected CWR lengths:

ADJUSTMENT OF CWR FOR TEMPERATURE CHANGE

Measured CWR temperature (degrees F)	Length of CWR String in Feet							
	400 to 500	500 to 600	600 to 700	700 to 800	800 to 900	900 to 1000	1000 to 1100	1100 to 1200
111 to 120	+.5"	+.5"	+1"	+1"	+1"	+1"	+1"	+1.5"
90 to 110	0"	0"	0"	0"	0"	0"	0"	0"
80 to 89	.5"	.5"	1"	1"	1"	1"	1"	1.5"
70 to 79	1"	1"	1.5"	1.5"	1.5"	2"	2"	2"
60 to 69	1"	1.5"	2"	2"	2.5"	2.5"	3"	3"
50 to 59	1.5"	2"	2"	2.5"	3"	3.5"	3.5"	4"
40 to 49	2"	2.5"	3"	3"	3.5"	4"	4.5"	5"
30 to 39	2.5"	3"	3.5"	4"	4.5"	5"	5.5"	6"
20 to 29	2.5"	3"	4"	4.5"	5"	5.5"	6"	6.5"
10 to 19	3"	3.5"	4.5"	5"	5.5"	6"	7"	7.5"
0 to 9	3.5"	4"	5"	5.5"	6.5"	7"	8"	8.5"

Note: + indicates increase, otherwise length is decreased.

C. ADJUSTMENT OF CWR BY MECHANICAL HEATING.

a. Rail may be expanded after it has been seated in the tie plates, but must be expanded before it is anchored. CWR should be heated and vibrated so that expansion is introduced from one end of each string to the other end in the direction of rail laying.

b. The amount of expansion of the CWR string may be calculated using the formula, or taken from the table, in Section B of this part. Space equal to the desired expansion for each CWR string should be provided between strings. Prior to heating a string, a minimum of 10 ties on the near end of the adjacent string should be anchored to hold it in place and avoid closing the expansion gap of the string being heated.

c. Heating should start at the beginning of the first CWR string and be steadily applied while moving forward until the required expansion has been obtained at the end of the string. Uniformity of expansion shall be controlled by marking each quarter of the string and monitoring expansion during heating. At the 1/4 point, 1/4 of the total required expansion should be attained, at the ½ point, ½ of the total expansion should be attained, etc.

d. Quarter points should be marked on the rail at the tie location closest to the 1/4 point and on the tie plate so that the amount of expansion can be accurately monitored. The tie plate used as a fixed reference must be securely spiked to prevent its movement when the rail expands.

e. If the required expansion is not achieved at the first 1/4 and/or at the midpoint, the string should be reheated, *beginning at the original starting point*, until sufficient expansion is obtained. Heating should not be done in a reverse direction. As the string is heated and the required amount of expansion is achieved, the string should be anchored in the same direction heating was done to prevent loss of expansion as the rail cools.

f. At the far end of the completely, successfully expanded string, a minimum of 10 ties should be immediately box anchored or have elastic fasteners applied after the gap is closed to maintain the proper expansion. The entire length of CWR shall be anchored in accordance with accepted practice before train operations can resume over the affected track.

D. ADJUSTMENT OF CWR THROUGH NATURAL TEMPERATURE CHANGE.

a. To adjust CWR which has already been in service, the adjustment requirement may be calculated by taking the difference between desired and installed temperatures of each CWR string and using the formula or table found in Section B of this part.

b. Rail temperature must be measured at intervals throughout the length of the CWR string and must be in the neutral rail temperature range (90 - 110 degrees Fahrenheit). To measure rail temperature, use approved rail thermometers placed on the base of the rail out of the direct sunlight. Thermometers should be left in place a minimum of 10 minutes to accurately determine the rail temperature. *Do not rely on ambient temperature readings.* Rail temperatures can be up to 50 degrees higher than ambient temperatures, depending on the strength of the sun.

c. Quarter points of the CWR string should be marked on the rail and tie plates as in Section C(d).

d. In the case of an expansion situation, joints on either end of the CWR string should be broken and the rail displaced to permit the expanding rail to bypass the adjacent rails. In the case of a contraction situation, a joint on one end of the CWR string should be broken and the near end of the adjacent rail on the fixed end of the string should be securely anchored.

e. Rail anchors throughout the length of the CWR to be adjusted must be removed to permit the desired rail movement. The CWR string should be vibrated to free the string from any potential binding points.

f. Once the CWR has moved the desired distance and the rail temperature is determined to be within the neutral range, the CWR should be re-anchored and connections to the adjacent rails or strings can be made as planned.

E MAKING REPAIRS TO SUN/HEAT KINKED TRACK.

Track which has kinked is under the influence of tremendous compressive forces. Extreme caution must be used while working on kinked track. Severe personal injury could result from the sudden reaction of kinked track while being torch cut or while breaking bolted connections in preparation for track repairs.

a. Cut both rails with a torch at the location of maximum displacement within the kink. Refer to the "Recommended Procedure for Stress Relieving Rail Under Compression" at the end of this Appendix.

b. Realign the torch cut rails, allowing the rail ends to bypass one another, if necessary.

c. For permanent repair, to ensure that expansion of the CWR is uniform throughout the length of the rail being adjusted, mark the rails incrementally in quarters from the location where the rails are bypassed.

d. Facilitate any additional expansion of the rail through removal of rail anchors (for emergency repair, remove all anchors for 200' either side of the kink; for more permanent repair, anchors should be removed up to 1/4 mile (1320') either side of the kink.

e. If the rail temperature is between 90 and 110 degrees, CWR adjustment can be completed. (If rail temperature is not within the neutral zone, it must be heated and adjusted as in (B) and (C) of this part.) Expansion should be uniformly distributed throughout the length of rail being adjusted. Expansion should be checked at the 1/4 points. Rail should be vibrated to ensure that it is not "hung-up" on any obstruction.

f. After determination is made that the CWR has expanded uniformly, the string may be re-anchored. Application of the anchors (or elastic fasteners) should begin at the points furthest away from the kink location and progress toward the kink area.

g. If heat kinked track is repaired outside of the neutral temperature zone it shall be slow ordered (a speed restriction put in place) at 10 mph until temperature adjustment can take place. A record of the adjusted temperature must be made and appropriately filed.

h. Rails which have been torch cut during track repair activity shall be removed from track within 24 hours and until removed, will require that a 10 mph speed restriction be placed on the track to protect operation.

F. REPLACEMENT OF DEFECTIVE RAILS OR WELDS.

In order to prevent the addition of rail to a CWR string when thermite welding, changing out a defective rail or installing a plug, precautions must be taken. In the case of thermite welding – the required gap shall be obtained by cropping the ends of the rail as needed, using a hydraulic rail stretcher to hold the rail and maintain the gap throughout the welding operation. In the case of rail change out or plug installation – the length of rail to be replaced must be measured prior to removal and the replacement piece cut to the exact same length.

G. MAINTENANCE OF CWR.

MAINTENANCE OPERATIONS WHICH DISTURB THE 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 most recent adjusted (de-stressed) rail temperature:

1) All out-of-face track raising, surfacing, comprehensive tie renewals, extensive adjustment to horizontal alignment or any disturbance to the ballast section (shoulders, cribs, etc.)

2) Selective procedures such as surfacing or lining where more than 5 consecutive ties are disturbed or where more than 5 intermittent ties in any 39' length of track are disturbed.

MAINTENANCE OPERATIONS WHICH NORMALLY DO NOT DISTURB THE TRACK STRUCTURE

The following maintenance operations do not constitute disturbing the track structure for the purpose of these instructions. Proper care must be exercised, however, to ensure that the stability of the track is not disturbed.

1) Ballast cleaning procedures on the shoulders or in the cribs using mechanized equipment, provided that a full ballast section is restored immediately behind the cleaning equipment.

2) Spot tie renewals where there are at least 4 properly spiked and anchored ties immediately adjacent on each side of the tie to be renewed and the ballast section throughout meets the requirements of **Section T213.103** in the Authority's Heavy Rail Transit Track Safety and Maintenance Standards. New ties must be properly tamped and the ballast properly dressed after completion of tie renewal.

3) Smoothing (spot surfacing) and/or lining where not more than 5 consecutive ties are disturbed and/or not more than 5 ties in any 39' of track are disturbed. Restore ballast section after completion of surfacing/lining.

RAIL TEMPERATURE

Before disturbing CWR track through performance of "Maintenance Operations which Disturb the Track Structure", the original installed rail temperature or the most recent adjusted rail temperature must be compared to the current (at the start of work) rail temperature as follows.

1) Temperature records must be reviewed to determine at what temperature the rail was originally laid, or the most recent adjusted rail temperature. The adjusted rail temperature is the temperature to which the rail was heated (or equivalently stretched) when longitudinal restraint (anchors or resilient spring clip fasteners) was applied. Adjusted rail temperature equals rail which has been de-stressed or anchored/fastened at neutral rail temperature (85 - 110 degrees).

2) Actual rail temperature shall be measured using a rail thermometer placed on the base of the rail out of direct sunlight.

3) The actual rail temperature shall be compared with the rail temperature of record. This comparison will determine whether or not the CWR track may be worked without making further temperature adjustments to the rail. Should the track buckle during maintenance activities, the rail must be cut, temperature adjusted (and recorded) and properly tamped.

RAIL ANCHORS

Following adjustment of CWR, all rail anchors must be reapplied before CWR track is returned to normal service. CWR is to be anchored as indicated below. (Resilient spring clip fasteners [Pandrol clips] are considered to be anchors for the purpose of this part).

1) Full box anchoring (both sides every tie) –
    a. On all curves 1500' radius and sharper;
    b. For 200' at each jointed end of CWR strings;
    c. For 200' each side of track crossings;
    d. For 200' each side of open floor bridges; or
    e. Through welded rail strings less than 400' long.

2) Box anchoring every other tie –
    a. Through the balance of each CWR string where full box anchoring is not specified in 1); and
    b. Across open floor decks on timber or steel structures where blocking has been installed between bridge ties and the deck is properly fastened with hook bolts.

3) Omit rail anchors entirely –
    In designated areas of zero longitudinal restraint (e.g., DeVaughn Flyover and Neponset River Bridge).

BALLAST SECTION

A full ballast section, as shown in **T213.31** and **T213.103**, shall be provided and maintained. Where necessary, a sufficient amount of new ballast should be distributed on track, in advance of surfacing operations. This will allow for ballast usage during surfacing and will permit regulating equipment to dress the ballast to the proper cross section prior to the track being placed back in normal operating condition.

PROCEDURES FOR THE PERFORMANCE OF WORK
WHEN THE RAIL TEMPERATURE IS EQUAL TO OR LOWER
THAN THE ORIGINAL INSTALLATION OR MOST RECENT
ADJUSTED RAIL TEMPERATURE

If the measured rail temperature is found to be no higher than the installation or most recent adjusted rail temperature, maintenance work as described in **T213.120** may take place while observing the following:

1) When surfacing CWR track, the track raise should be kept to the minimum necessary to obtain a good profile, but should not exceed 1-1/2". If more than a 1-1/2" raise is required, additional raises should be made with time between to allow for train-load stabilization of the track structure.

2) Both rails of CWR track should be raised simultaneously, the cross level maintained throughout any surfacing operation. Raising track without then immediately and fully tamping all ties and compacting cribs and shoulders should be avoided.

3) When renewing ties, not more than 3 consecutive ties nor more than 8 ties in any 39' of track are to be renewed in any one pass. Should more than the 3 and 8 need renewal, additional passes should be made.

4) Before track is returned to normal service, all ties installed shall be re-spiked (if they are not already pre-plated), tamped, have rail fasteners applied and the proper ballast section should be restored.

5) A record should be made indicating the temperature that the track was worked. The worked temperature is not to be considered as the adjusted temperature nor recorded as such.

6) An appropriate speed restriction (slow order), not to exceed 25 mph, shall be placed on all track worked. The restriction shall remain in effect for a minimum of 24 hours. If an inspection of the work area reveals no exceptions after 24 hours, the speed of the track may be upgraded to the posted speed for the territory.

PROCEDURES FOR THE PERFORMANCE OF WORK
WHEN THE RAIL TEMPERATURE IS HIGHER
THAN THE ORIGINAL INSTALLATION OR MOST RECENT
ADJUSTED RAIL TEMPERATURE

If measured rail temperature is higher than the original installation or most recent adjusted rail temperature, CWR may be adjusted before or during maintenance operations using the following procedures.

1) Disconnect or cut and line the ends of CWR strings out of the tie plates to clear adjoining rail ends.

2) Remove all rail anchors/spring clip fasteners for the area to be adjusted.

3) After the track has been worked, tamped and lined, rail closures should be made, adjusting the CWR as required.

4) All anchors/fasteners must be reinstalled to prescribed standards before the track is returned to normal service.

5) The proper ballast section must be restored before the track is returned to normal service.

6) In the event work is performed through only part of a CWR string, the entire string is to be freed and the un-worked portion of the string is to be loosened in its tie plates before making string closure and re-anchoring/refastening.

7) The rail temperature of each CWR string which is adjusted is to be measured and recorded, using a standard rail thermometer. The thermometer should be laid on the base of the rail out of the direct sun and left long enough to get an accurate reading.

8) If the rail is not adjusted before or during the maintenance operation, a 10 mph speed restriction will be placed on the work area when the track is returned to service and the track must be inspected after the passage of the first train. The 10 mph will remain in effect for 24 hours. Provided no exceptions are noted after the 24 hours, the speed may be upgraded to 30 mph and will remain so for 48 hours. If no exceptions are then noted, the restriction may be lifted and the track operated at posted speed.

9) In the event that the original installation or most recent adjusted rail temperature is unknown and the *existing* rail temperature is 80 degrees or above, these instructions shall apply.

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(See following page)

MBTA

MAINTENANCE OF WAY DIVISION

Record of Welded Rail Installation or Disturbance of CWR in Track

Date:_____ Line:_____
Location:_____ Stationing:_____

Work Executed:_____

Amount of Rail Removed:_____
Amount of Rail Installed:_____
Rail Temperature at Installation:_____

Was rail properly anchored at installation? (Yes / No) If No,
explain:_____

Was ballast section per MBTA Standards?
(Yes / No) If No, explain deficiency:_____
Comments:_____

_____

_____
Supervisor/Foreman (PRINT NAME)

_____
Supervisor/Foreman (SIGN NAME)