WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

TRST 1000-SUPPLEMENAL TRACK CONCEPTS MANUAL

TRST-1000 - Volume 3

5.4.25 Guarded Curves and Restraining Rails

5.4.25.1 It is customary in transit rail track design to provide a continuous guard rail or restraining rail through sharp radius curves. The restraining rail provides additional steering action using the flange of the wheel that is riding on the inside rail of the curve. By doing so, the Lateral over Vertical (L/V) ratio at the outer wheel can be reduced, which will both reduce wheel and rail wear and deter possible derailment.

Note: WMATA uses two forms of restraining rail in its system being the Horizontal and Vertical designs. Both are located on mainline and yard tracks, weather ballasted or direct fixation. The older design in the process of being replaced, is a horizontal 115 lbs. tee rail bolted on a chair adjacent to the low running rail. The newer design is 132 lbs. bolted through a web spacer block web connect to the low running rail.

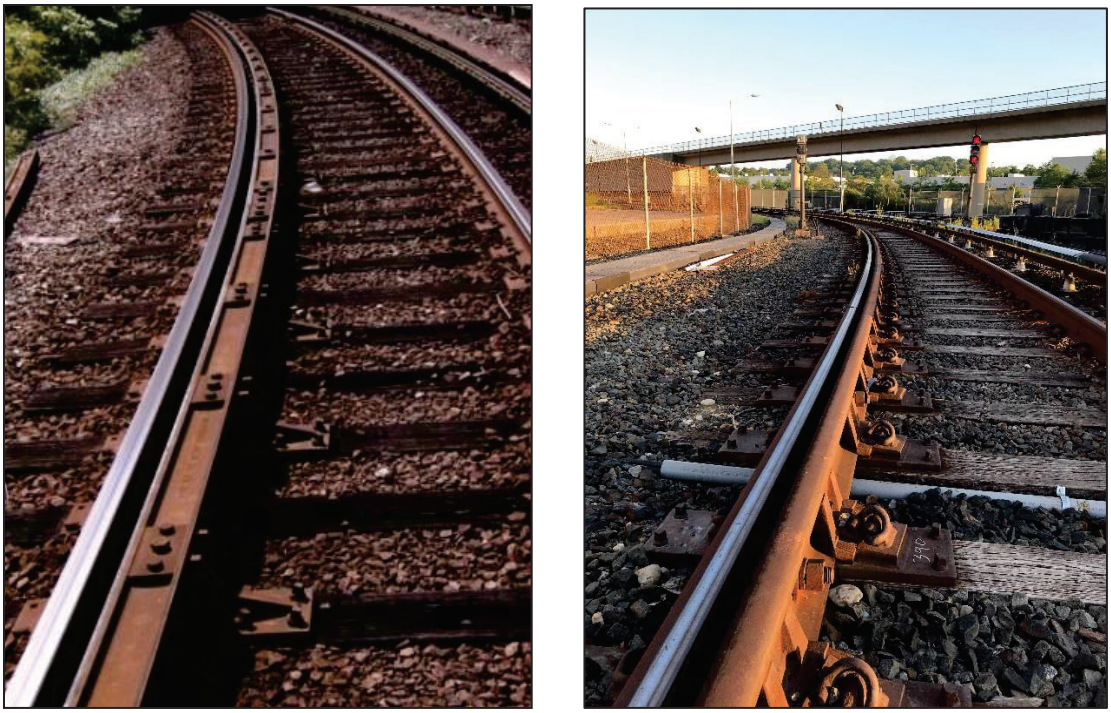

Figure 5.4-545, Guarded Curves and Restraining Rails (Horizontal and Vertical types)

5.4.25.2 In a typical transit installation, the restraining rail is installed inside the gauge line of the curve's low rail (see Figure 5.4-55) to provide a uniform flangeway, typically (1-3/8 to 2-3/8 inches) wide. The working face of the restraining rail bears against the back side of the inside wheel, guiding it toward the curve's center

and reducing the lateral contact force of the opposite outside wheel's flange against the high rail of the curve. This essentially divides the lateral force between two contact surfaces and greatly reduces the rate of lateral wear on the high rail. It also reduces the angle of attack between the wheel flange and the rail. In all cases, the use of restraining rail in a curve will reduce the tendency of the leading outside wheel to climb the high rail, thereby preventing possible derailments.

5.4.25.3 The radius threshold for employing guarded track varies between rail transit agencies. Other operations relate the need for guard rails to vehicle speed and the amount of unbalanced superelevation, hence considering the lateral portion of the L/V ratio before deciding that the expense of guarding is warranted.

Note - L/V: The Vertical Force is a result of the vehicle weight pushing downward on the wheel and rail, keeping the vehicle on the track.

Note - L/V: The Lateral Force pushing outward horizontally, (made up of centrifugal force and frictional force off the low rail) attempts to derail the vehicle and is resisted by vertical strength of the high rail.

Note – L/V: When the L/V ratio exceeds the Nadal limit, (0.8) the vehicle will derail.

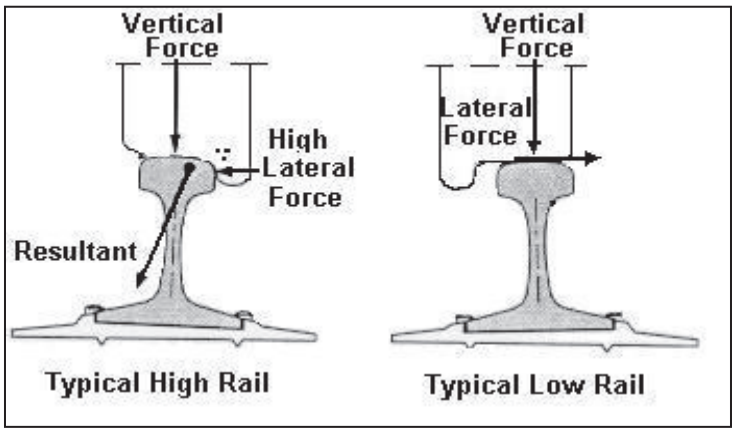

Figure 5.4-556, Tight Curve creates High Lateral Forces on the High Rail

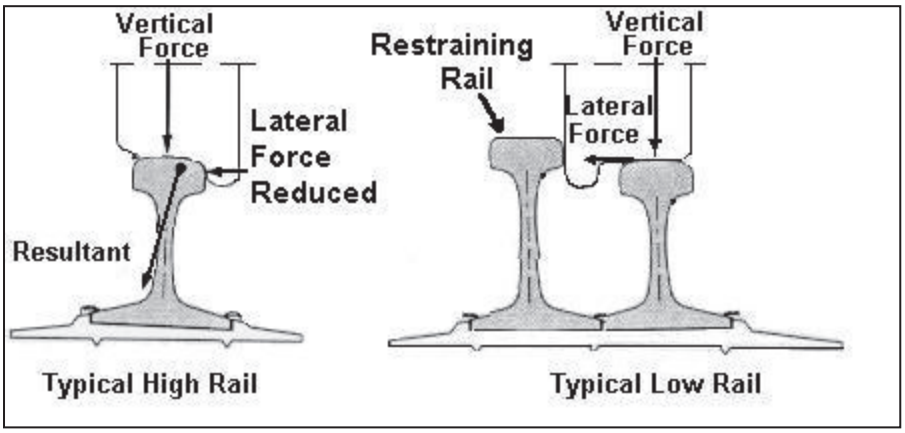

Figure 5.4-567, Restraining Rail reduces the High Lateral Forces on the High Rail

5.4.25.4 Curve guarding does not usually terminate the point of tangency of a curve; it extends some distance into the adjacent tangent track. This distance depends on a number of factors including the resistance to yaw of the vehicle's suspension system. The conservative designer will extend the restraining rail a distance equivalent to one truck center into the tangent track, typically about (35 ft.). When the curve is spiraled, the need for guarding typically ends long before the spiral-to-tangent location. In such cases, curve guarding can usually be terminated a distance equivalent to one truck center beyond the point on the spiral where the instantaneous radius matches the curve guarding threshold.

5.4.25.5 The criteria for beginning curve guarding on the entry end of the curve is typically the same as for the exit end, accounting for the possibility of occasional reverse running train operation. As a guideline, the minimum guarding should begin at the tangent-to-spiral location of a spiraled curve so that the vehicle trucks are straight prior to entering the guarding threshold spiral curve.

5.4.25.6 If restraining rail is required on a system due to restricted sharp radius track curves, then a similar scenario should be undertaken using the parameters of the vehicle truck and track system to establish the flangeway. For extremely sharp radius curves requiring double restraining rails, the same procedures are required to establish both flangeway widths. It should be noted, however, that double guarding is not implemented on WMATA. Truck rotation about an initial contact of the inside lead axle wheel on the restraining rail face is possible if the designer elects to provide clearance at the outside lead axle wheel. The Association of American Railroads (AAR) wheel gauge requires a wider flangeway than the transit wheel gauge due to basic clearances between the wheel and the rail. Under these same conditions, it may be necessary to increase track gauge so as to provide

either wheel contact on both the restraining rail and the outside running rail or to provide clearance between the outside wheel and its running rail.

5.4.25.7 As a guideline, it is recommended that the inside restraining rail flangeway width be set to provide dual wheel contact so that the inside back face of wheel makes contact with the restraining rail face while the outside wheel is simultaneously contacting the gauge corner of the outside rail. This will divide the lateral steering force between both restraining rail and running rail (40% and 60% is recommended). In practice, this condition may not be immediately obtained, however, rail wear at either the outside running rail or inside restraining rail will eventually balance the curving action.

5.4.26 Double Guarding at Turnouts

It must be noted that within turnouts at the frog insert, double guarding does occur by turnout design with the opposing guard/check rail. At this point the guard face gauge must not exceed 53-1/4" otherwise the passing train wheel set risks being squeezed between the guard lines of the frog point and the guard face of the guard / check rail. This can cause a "pinch out" derailment or a widening of the back to back wheel gauge, which can lead to an eventual derailment. To correct this condition the flangeway between the guard. /checkrail and running rail will be increased so that a passageway greater than the wheel back to back gauge is preserved.

5.4.27 Curve Double Guarding (Not applied at WMATA)

5.4.27.1 Some transit agencies "Double Guard" extremely sharp curves, placing a guard or restraining rail adjacent to the high rail as well as the low rail. These installations are designed to counter the tendency of the second axle on a truck to drift toward the center of the curve, exacerbating the angel of attach of the outside wheel on the leading axle. In a double restraining rail installation, the restraining rail alongside the inner rail shifts the leading axle of the truck toward the center of the curve. The outer restraining rail then guides the trailing axle away from center, helping to ensure that the truck is reasonably square to the track, that both axles are in a nearly radial orientation, and that the truck frame is rectilinear rather than parallelogramed. In superelevated, sharp radius track curves where the vehicle speed is reduced, the vehicle truck may tend to hug and climb the low rail. The outer restraining rail reduces this derailment potential.

5.4.27.2 As a guideline, a typical threshold for consideration of double guarded track is for curves with radii of (100 to 125 ft.). However, care must be taken when double guarding a curve.

a) For example:
   i. Wheel gauge is 55.96 inches.
   ii. Standard gauge is 56.5 inches.
   iii. Delta gauge vs. wheel gauge is 0.5354 inches.
   iv. Wheel flange width at 5/8 inch from wheel centerline = 1 3/8 inches.
b) Therefore, minimum guard check gauge is 55.96 inches less 1.375 inches = 54.59 inches for balanced contact.
   i. With gauge at 56.5 inches, this sets the restraining rail gap at 1.91 inches = (nominally) 2 inches.
   ii. With gauge at 57.25 inches, this sets the restraining rail gap at (nominally) 2-3/4 inches.

5.4.27.3 This gap (2 inches) should be used for all curves greater than 350 ft. radius. For curves less than 350 ft. radius, the gap should be widened to 2 3/4 inch.

5.4.28 Restraining Rail Inspection

5.4.28.1 It is recommended that Restraining Rails be installed inside the low rail on all mainline curves with a radius of less than 800 ft. Where installed, each end of the rail must start at least 35 ft. ahead of tangent to spiral. Where less than 35 ft. is available, the maximum possible length will be installed.

5.4.28.2 Restraining Rails are effective only if they limit wear on the gauge side of the high rail.

5.4.28.3 The effectiveness of the restraining rail on any curve should (can) be judged by the amount of wear on the high rail of the curve. If the wear is minimal, the restraining rail is doing its job.

5.4.28.4 All chairs must be checked to be sure that they are properly supporting the restraining rail and that all anchor bolts (direct fixation track) are tight, rail holding bolts are tight and that special plates and welds are not cracked or broken. Integrity of the modified Direct Fixation (DF) fastener in direct fixation track should be checked the same as for standard DF fasteners.

5.4.28.5 On ballasted track the condition of the ties where the chairs are anchored must be accessed to confirm that anchorage is tight and stable.

5.4.28.6 Restraining rail chairs must be spaced no more than 5 ft. apart.

5.4.28.7 Chairs are adjustable to compensate for running rail wear and for restraining rail wear.

5.4.28.8 Check that the restraining rail is not more than 1 inch higher and not more than 1/16 inch lower than the plane of the top of the running rails.

5.4.28.9 A thin even layer of lubricant on the rail head of the restraining rail indicates proper lubrication. If excess grease is evident on restraining rail or if restraining rail shows evidence of excess wear, rail lubricator should be checked.

5.4.28.10 Broken, excessively or irregularly worn restraining rails can cause damage to the wheels of equipment and must be replaced immediately.

5.4.28.11 Check that the bearing face of the restraining rail is well lubricated. If required, lubricated with a low electrical conductivity lubricant.

5.4.28.12 Check that the distance between head of low rail and restraining rail is at 2 inches, with a clear flange way depth of at least 2-1/4 inches. Add shims as necessary to maintain this flangeway measurement.

5.4.28.13 Gap/width must not be less than 2 inches (+/- 1/8 inch).

5.4.28.14 Any indication of movement of the restraining rail must be investigated to determine cause and corrective action must be taken as soon as possible to avoid undue wear on high rail of curve. Cracks occurring in the web area of restraining rail should be inspected and reported.

5.4.29 Emergency Guard Rails (EGR)

5.4.29.1 Emergency Guard Rails are used on all Main Track Ballasted Bridges and Direct Fixation Aerial Structures, and ballasted track in the vicinity of abutments for overhead structures such as bridges and are governed by the following:

a) On all single-track structures two Emergency Guard Rails are needed.
b) Rails are placed, one inside of each running rail.
c) On multiple track structures each exterior track has one EGR inside of the running rail farther from the edge of the structure.
d) Treat multiple track structures with over 4 1/2 inches opening between decks as single-track structures.
e) EGR is not used in special trackwork.