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# Rail Neutral Temperature Maintenance Guidelines

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## Summary

Transportation Technology Center, Inc. (TTCI) has developed recommended guidelines for rail neutral temperature (RNT) maintenance involving the readjustment of low RNT conditions to target values. Target readjustment allows the RNT to be restored to 20 °F below the designated rail laying temperature (DRLT), or higher, in accordance with a methodology for track-buckling prevention.

The recommended guidelines are based on the RNT maintenance methodology developed and validated by TTCI to calculate RNT readjustment requirements and estimate existing RNT conditions. The methodology and guidelines focus on increasing RNTs that have been reduced, sometimes substantially, from rail added during cold weather broken rail repairs or defect removal. The guidelines are also applicable to restressing known or suspected low RNT conditions where rail was not added during cold weather. Stress relieving high compressive forces during hot weather are also discussed.

The RNT maintenance guidelines address four RNT readjustment conditions: (1) readjustment following the methodology requirements, but without de-anchoring the rail when the existing RNT is not less than 20°F below the DRLT, (2) readjustment following the methodology requirements and including de-anchoring when the existing RNT is more than 20°F below the DRLT, (3) readjustment when the methodology prescribed requirements are not available, and (4) special conditions when the methodology prescribed requirements do not apply.

Increasing a low RNT to a target condition involves adding tension to the rail. Tension is induced by cutting a gap in the rail, unfastening/de-anchoring a length of rail on both sides of the gap, and closing the gap by pulling and/or heating the rail. The gap width and de-anchoring distance are based on the difference between the existing and desired readjusted RNT calculated by the RNT maintenance methodology. The methodology also calculates the RNT before a rail break or before rail is cut from the measured gap width and rail temperature at the time of the break/cut. The pre-break/cut RNT values are required by the continuous welded rail (CWR) policies of some railroads and provide much needed RNT data to the industry and the research community. The methodology's computational aspects have been incorporated into a program called CWR-Adjust<sup>®</sup> and have been further simplified with pull-cards developed for railroad specific field uses.

\*CWR-Adjust<sup>®</sup> (computer program) is a registered copyright (2008) of the Transportation Technology Center, Inc.,  
Pueblo, Colorado.



**INTRODUCTION**

Effective management of thermally induced longitudinal forces in CWR is essential for safe and reliable track performance. One of the goals of the Longitudinal Rail Stress Strategic Research Initiative managed by TTCI has been to define potential maintenance practices based on engineering principles for controlling thermal forces and the risk of track buckling. The guidelines in this *Technology Digest*, developed with support from Dr. Andrew Kish of Kandrew, Inc. Consulting Services, focus on techniques for maintaining RNT at levels that minimize buckling potential.

**RNT AND TRACK BUCKLING**

The RNT is the rail temperature at which the thermal force is zero. Thermal forces are generated when the rail temperature differs from the RNT and the force magnitude is governed by the rail area (larger rail sections produce more force per degree change than smaller sections) and, most importantly, the difference between the rail temperature and RNT, commonly designated as  $\Delta T$ .

The ability to increase, or readjust, a low RNT to the railroad specified DRLT minus 20°F, or higher, is useful. However, maintaining the RNT at a target condition is difficult in practice for two reasons: (1) the actual RNT condition is almost never known, because of the lack of RNT measurement technology, and (2) the information required to readjust the RNT to a specific value is normally not known by track maintenance personnel. These issues are addressed with an RNT maintenance methodology based on the technical relationships that exist between the RNT, rail temperature, and the rail/track longitudinal resistance.<sup>1,2</sup>

**RNT MAINTENANCE METHODOLOGY**

Tension that is released when the rail breaks or is cut at temperatures below the RNT produces a gap in the rail and causes a reduction in the RNT in the vicinity of the break/cut. The gap width and distance away from the break/cut where the RNT is reduced are proportional to the tensile force (rail size and  $\Delta T$ ) and longitudinal resistance.<sup>3</sup> RNT readjustment is the process of retensioning the rail.

TTCI has developed a methodology to determine how much rail to remove and the distance to de-anchor when readjusting a low RNT produced by adding rail during a cold weather rail repair. The methodology involves the following steps:

**Step 1:** Measure the rail break temperature and gap width at the time of the break, or as soon as possible thereafter.

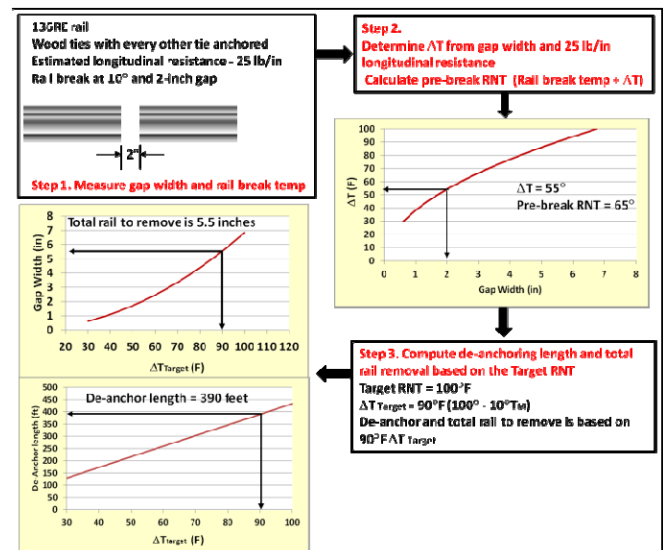
**Step 2:** Calculate the pre-break/cut  $\Delta T$  and RNT from the rail size, gap width, and estimated longitudinal resistance using the values in Table 1 that have been compiled from numerous field tests.<sup>4</sup>

**Step 3:** Compute the de-anchoring length of each side of the break and rail removal amount to readjust the RNT to the difference between the rail break temperature ( $T_M$ ) and the target RNT ( $\Delta T_{Target}$ ).<sup>5</sup>

**Table 1. Longitudinal Resistance Values**

Fastener Condition	Resistance (lb/in)
Every Other Wood Tie Box Anchored (EOTA) weak	15
EOTA average	20
EOTA strong	25
Every Wood Tie Box Anchored or Elastic Fastener (ETA) weak	25
ETA average	30
ETA strong	35
Concrete Tie Elastic Fastener (CTEF) weak	30
CTEF average	35
CTEF strong	40

Figure 1 shows an example of the methodology process where a 136RE rail breaks at 10°F, leaving a 2-inch gap, and the longitudinal resistance is estimated at 25 lb/inch. A pre-break RNT of 65°F is calculated from the gap width and  $\Delta T$ . The total amount of rail to remove is 5.5 inches, and the de-anchoring length both side of the break is 390 feet, based on the 90°F  $\Delta T_{Target}$ .



**Figure 1. Example of Cold Weather Rail Break Methodology Process**

The RNT readjustment methodology has been automated in a computer program called CWR-Adjust<sup>®</sup> to facilitate its use as a maintenance tool.<sup>6</sup> Program inputs include the rail break/cut temperature, track type, rail size, anchor/fastener condition, gap width and target RNT. The outputs include the pre-break/cut RNT and the total gap width (amount of rail to remove) and de-anchoring distance to readjust to the target RNT.

The RNT readjustment methodology automated in CWR-Adjust<sup>®</sup> has been further simplified for field use with the development of pull-cards. The cards are railroad specific and intended to provide basic RNT readjustment information without having to use the computer program.

**RNT READJUSTMENT GUIDELINES**

The RNT maintenance guidelines address four RNT readjustment conditions: (1) readjustment following the methodology requirements, but without de-anchoring the rail when the existing RNT is not less than 20°F below the DRLT, (2) readjustment following the methodology requirements and including de-anchoring when the existing RNT is more than 20°F below the DRLT, (3) readjustment when the methodology prescribed requirements are not available, and (4) special conditions when the methodology prescribed requirements do not apply.

Guidelines for RNT readjustment following cold weather rail breaks/cuts for the four above mentioned conditions are as follows:

**Condition 1:** CWR-Adjust or pull-cards, i.e., the RNT methodology, show the pre-break/cut RNT is not more than 20°F below the DRLT. The readjustment procedure is to close the gap by pulling and/or heating without de-anchoring.

**Example:** A 136RE rail breaks at 40°F, the gap width is 2 inches, and the DRLT is 100°F. The CWR-Adjust program gives the pre-break/cut RNT as 88°F, which is within the prescribed DRLT minus 20°F safe range (Figure 2). The rail ends are pulled together and welded without de-anchoring to restore the pre-break/cut RNT.

Figure 2. CWR-Adjust Data for Condition 1 Example

**Condition 2:** The methodology indicates the pre-break/cut RNT is below the DRLT minus 20°F limit. The methodology prescribed total gap width to close and de-anchoring requirements now apply. Interim repair options are: (a) install a plug rail to close the gap (rail is added equivalent to the gap width), or (b) if possible, pull the rail ends together without de-anchoring. In both cases, the final readjustment should be performed before the onset of hot weather according to the provisions in Table 2. In case (a), the methodology prescribed gap width and de-anchoring requirements apply to the final readjustment. In case (b), the methodology gap width

requirement is decreased by the amount the rail was initially pulled together.

**Example:** Using the example in Figure 1, the methodology gives the pre-break/cut RNT as 65°F, which is below the 100°F DRLT minus 20°F threshold of 80°F. The methodology specifies a total gap width of 5.5-inches and a de-anchor length of 390 feet on both sides of the gap to readjust to the 100°F target. In this example, the rail is pulled to close the 2-inch gap without de-anchoring as the interim repair. The rail is de-anchored, and the remaining 3.5 inches are removed at a later date when the rail temperatures are higher to facilitate final gap closing. It should be noted that if the target RNT is reduced to the minimum limit of 80°F (70°F  $\Delta T_{Target}$ ), the total gap width is reduced to 3.3 inches, and the de-anchoring distance is reduced to 300 feet, as Figure 3 shows.

Table 2. Maximum Return Temperature for RNT Readjustment<sup>1</sup>

Rail Break/Cut Temperature (°F)	Maximum Readjustment Temperature (°F)
40	125
30	120
20	115
10	110
0	105
-10	100
-20	90
-30	80

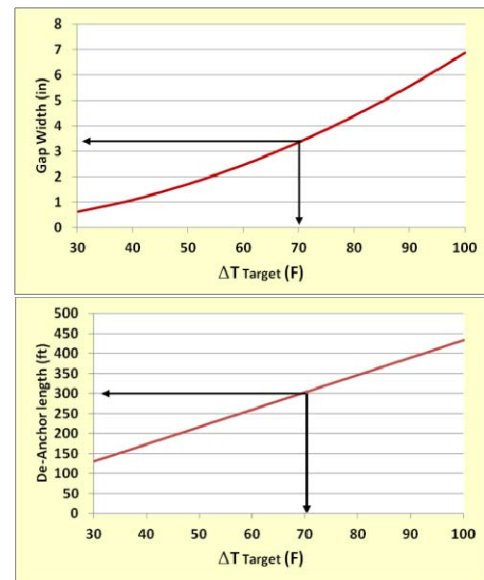


Figure 3. Gap Width and De-Anchoring Data for Condition 2 Example with Reduced Target RNT

**Condition 3:** If CWR-Adjust or pull-card readjustment information is not available, perform either interim repair method from Condition 2 and use the following final adjustment procedure:

- Apply reference marks at ± 12 inches from the location being cut/readjusted, and apply match marks at ± 390 feet

away from the cut on the rail base extending to the tie plate or concrete tie insulator.

- Open the joint or cut the rail and remove rail until it stops expanding (the rail temperature should be above the rail break/cut temperature and the rail is in compression).
- De-anchor 390 feet of rail in both directions and continue cutting until the rail stops moving.
- Measure the rail temperature and determine the amount of rail removed from the reference marks. Additional rail will be removed according to the Table 3 temperature differential if the rail temperature is below the DRLT. Measure the match mark rail movement at both ends, and add the end movement and weld allowance to the Table 3 values for the total gap size.
- Cut out the additional rail, pull or heat the unfastened rail length to close the gap to the welding allowance, reapply anchors/fasteners, and make the weld.

**Table 3. Additional Rail to Remove**

Temperature Differential (°F)	Additional Rail to Remove (inches)
15	1
20	1 1/4
25	1 1/2
30	1 3/4
35	2
40	2 1/4
45	2 1/2
50	3
55	3 1/4

**Example:** A 136RE rail plug is installed at 10°F to close a 3.5-inch rail break gap. The DRLT is 100°F, but without access to the methodology, the pre-break RNT is unknown. The crew returns at a rail temperature of 70°F to make the final RNT readjustment. The difference between the readjustment rail temperature (70°F) and the DRLT (100°F) is 30 degrees; therefore, using Table 3, 1 3/4 inches of rail must be removed in addition to the rail removed from the de-anchored rail expansion. The end movement match marks show 1/4-inch of movement at both ends, and the weld gap is 1 inch. Therefore, a final 3 3/4-inch gap is cut and the rail ends are pulled to the 1-inch weld gap, re-anchored, and welded.

**Condition 4:** Special cases when CWR-Adjust has theoretical limitations and does not apply are as follows:

- Defects/breaks clustered closer than 800 feet — Apply the Condition 3 process to each location independently.
- Defects/breaks within 400 feet of a structure such as switches, rail crossings, and bridges — Follow the Condition 3 procedure, de-anchoring 390 feet on the nonstructure side of the break and up to the structure on the other side.
- Defects/breaks occurring on both rails within 200 feet of each other — Condition 1, 2, or 3 guidelines are applicable; however, the maximum readjustment rail

temperature guideline in Table 2 is modified because of the increased risk of buckling from both rails having a reduced RNT condition. The maximum return temperature for readjustment if both rails have been cut/broken with 200 feet of each other is determined as:

$$T_{\text{RETURN}} = (T_{M1} + T_{M2})/2 + 70^{\circ}\text{F}$$

Where:  $T_{M1}$  and  $T_{M2}$  are the respective rail break/cut temperatures. Example: if one rail breaks or is cut for defect removal at 10°F, and the other rail breaks or is cut at 30°F, the maximum rail temperature for final readjustment is 90°F.

The Condition 3 procedure should also be followed when removing rail to reduce compressive forces not associated with a broken or cut rail during hot weather.

## CONCLUSIONS

TTCI has developed and validated a methodology and associated guidelines for readjusting RNT to target levels, using the rail thermal force and RNT response to a cut or break. The methodology computations have been incorporated into the CWR-Adjust program, which provides track maintenance personnel with rail removal and de-anchoring information. The resulting guidelines are based on engineering principles and practical considerations that provide an approach for effective CWR thermal force management.

## REFERENCES

1. Read, D. and A. Kish. April 2005. "Methodology for More Efficient CWR Management through Improved De-stressing and Neutral Temperature Readjustment, Part 1," *Technology Digest* TD-05-010, AAR/TTCI, Pueblo, CO
2. Read, D. and A. Kish. April 2005. "Methodology for More Efficient CWR Management through Improved De-stressing and Neutral Temperature Readjustment, Part 2," *Technology Digest* TD-05-011, AAR/TTCI, Pueblo, CO
3. Kish, A. and G. Samavedam. January 2005. "Improvements in CWR Destressing for Better Management of Rail Neutral Temperature," *Journal of Transportation Research Board*, No. 1916, pp 56-65, Washington, D.C.
4. Read, D. December 2011. "SRI 7B Rail Stress Management Status Report for Heavy Axle Load/Engineering Research Committee," Presentation at AAR/HAL/ERC Fall Meeting, Pueblo, CO
5. Read, D. and A. Kish. May 2008. "De-Anchoring Guidelines for the Readjustment of Rail Neutral Temperature," *Technology Digest* TD-08-017, AAR/TTCI, Pueblo, CO
6. Read, D. and A. Kish. May 2008. "Automation of Rail Neutral Temperature Readjustment Methodology for Improved Continuous Welded Rail Performance," *Technology Digest* TD-08-018, AAR/TTCI, Pueblo, CO

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