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Automation of Rail Neutral Temperature Readjustment Methodology for Improved Continuous Welded Rail Performance

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Summary

Transportation Technology Center, Inc. (TTCI) has written software to provide track maintenance forces with the basic information required to readjust rail neutral temperature (RNT) based on minimal input information. The applied technology will enhance current RNT maintenance practices by providing information that is critical, but generally unknown by field forces.

Over the past several years, research activity by TTCI performed under the Association of American Railroads Rail Stress Management Strategic Research Initiative, has examined RNT behavior and maintenance practices.

Tensile forces in continuous welded rail are released when the rail breaks or is cut to remove a defect at rail temperatures below the RNT. The release of tension produces a gap in the rail and causes a reduction of the RNT. Rather than attempting to re-tension the rail and close the gap during the repair process, it is often necessary to eliminate the gap by installing a plug rail that is longer than the rail removed. It is currently common industry practice to remove the excess rail that was added by the plug rail before the onset of warm weather to avoid high compressive forces and the potential for buckled track.

Removing the excess rail is a straightforward procedure that, when properly carried out, will restore the RNT to the pre-break condition, but does not necessarily readjust the RNT to the designated rail laying temperature or other target value. The track maintainer is at a disadvantage if required to readjust the RNT to a specific value as this requires knowledge of the pre-break RNT, the length of rail over which the RNT was affected by the release of tension, the required distance to de-anchor and the total gap width to recover. Maintenance personnel in most cases will not know or have access to this information, but it can be estimated from the relationships that exist between the rail longitudinal thermal force, rail temperature, and rail longitudinal resistance.

Concepts derived from analytic and test results and reported previously in other *Technology Digests* have been incorporated into a simple and user-friendly program that provides maintenance personnel with the pre-break RNT, tells how much rail to de-anchor, and the total gap width to recover in order to readjust the RNT to an approximate value.

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INTRODUCTION

RNT is the rail temperature at which there is zero longitudinal thermal force in continuous welded rail (CWR) and governs the magnitude of tensile or compressive forces that can develop at temperature extremes. Accordingly, maintenance of the RNT is critical if rail thermal forces are to be controlled and managed effectively. Over the past several years, research activity by TTCI performed under the Association of American Railroads Rail Stress Management Strategic Research Initiative, has examined RNT behavior and maintenance practices. Results from this work have been applied in the development of technology intended to provide track maintenance forces with information needed to readjust the RNT to designated values. Readjustment of the RNT to a specified value, as opposed to simply restoring it to a pre-existing condition, is necessary if the RNT is to be maintained within defined limits and may be considered to be a maintenance best practice.

Rail Neutral Temperature Readjustment Methodology

The readjustment technology is automation of the RNT readjustment methodology that has been documented in several digests and research papers.[1,2,3] To summarize, the methodology quantifies relationships between rail temperature, rail thermal force and rail longitudinal resistance, defines the RNT response to a broken or cut rail, and estimates the pre-break RNT and RNT influence zone (L_D). Figure 1 shows the essential concepts, which include the following:

- Rail thermal tension is determined by the rail area and the difference between the RNT and rail temperature (ΔT).
- The gap produced in the rail by the release of tension during a rail break or cut is a function of the level of tension and the longitudinal resistance provided by rail anchors/fasteners and the ballast section. The gap is, therefore, an indicator of the pre-break RNT, if the rail break temperature is known and the longitudinal resistance is estimated.
- The release of tension also causes the pre-break RNT to drop to the rail break temperature at the gap. The difference between the pre- and post-break/cut RNT diminishes with distance away from the gap by the incremental longitudinal resistance. This distance on each side of the gap over which the RNT was affected is referred to as the influence zone (L_D) and is a function of the ΔT and longitudinal resistance.
- The post-break RNT changes at a linear rate and then asymptotically approaches zero-change due to nonlinearity of the longitudinal resistance. The methodology ignores the nonlinear response and a linear approximation of the LD is used.
- The L_D and post-break RNT profile are based on the assumption of a relatively uniform pre-break/cut RNT profile.
- The minimum distance to de-anchor during the readjustment process is half the L_D.[4]

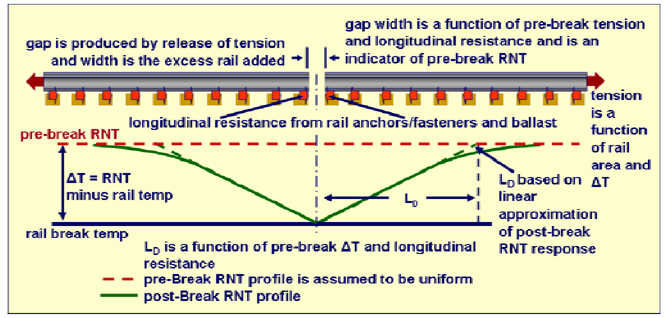

Figure 1. RNT Readjustment Methodology Concepts Related to a Cold Weather Rail Break

Readjusting the Rail Neutral Temperature to Designated Values

RNT readjustment is the process of restoring tension that was lost during the rail break/cut. Figure 1 shows that tension applied to recover the gap width, along with adequate de-anchoring of the L_D, restores the RNT to the pre-break level. But the RNT methodology can be applied to readjust the RNT to a specified level by changing the gap size and L_D. For example, if the pre-break RNT in Figure 1 was lower than desired, the gap width would be increased to reflect a higher pre-break tensile force and ΔT. The higher ΔT also generates a longer L_D and the increased tension required to close the wider gap over a longer distance produces a higher RNT. Conversely, the gap width can be decreased (not all excess rail removed), if it is desired to reduce a high RNT condition.

Rail Neutral Temperature Methodology Automation

A menu driven computer program has been written to automate the RNT methodology. From the first menu (Figure 2), the user selects optional work scenarios; i.e., cold weather rail break repair/defect removal, which is the readjustment of a low RNT condition due to cold weather rail repair during either the repair or later, or hot weather de-stressing to relieve compressive forces in a hot rail.

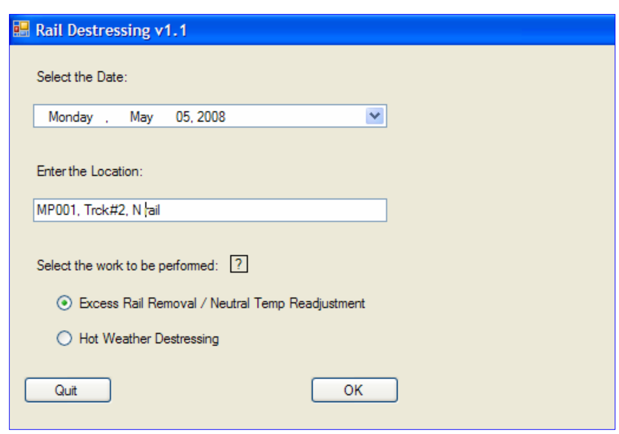

Figure 2. Work Description Menu

User Input Menu

The next menu prompts the user for the required rail break/cut information, including drop down menus for track type (wood with every other tie anchored, wood with every tie anchored, concrete, wood with elastic fasteners), anchor/fastener condition (weak, average or strong), and rail size. These inputs establish values for the rail area and longitudinal resistance variables. Next is a yes/no frozen ballast query that doubles the longitudinal resistance if the ballast is frozen. The gap width is entered which is the amount of excess rail added. Next the rail temperature at the time of the break/cut is entered. The final input values are the designated rail laying temperature (DRLT) and the minimum RNT desired from the readjustment. The minimum RNT may be the same as the DRLT, or some lesser value, but is not recommended to be more than 20ºF lower than the DRLT.

A sample input is shown in Figure 3 for wood tie track with every other tie anchored, average anchor condition, 136RE rail, ballast not frozen, rail break at 12ºF, gap of 3½ inches, DRLT of 95ºF, and minimum readjusted RNT of 75ºF (DRLT minus 20ºF).

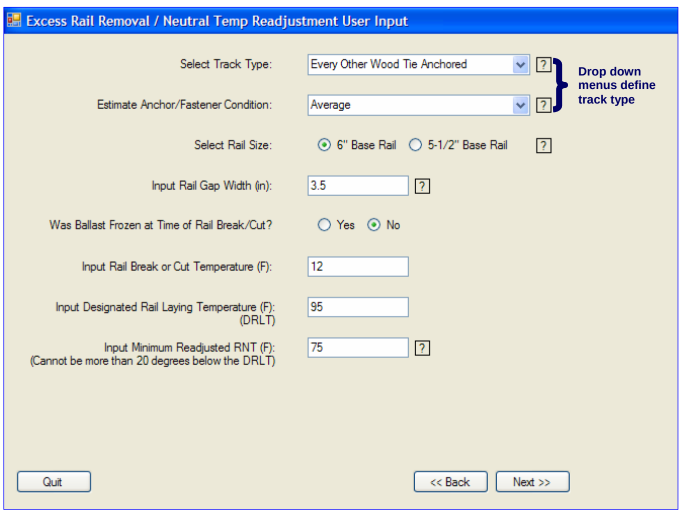

Figure 3. Cold Weather Repair Input Menu

The program logic is to readjust the RNT to the pre-break condition if the pre-break RNT is higher than the desired minimum RNT. Or, the program will readjust to the minimum value if the pre-break RNT is lower than the RNT minimum.

Program Output

The program output module gives the two essential readjustment parameters; i.e., the total gap width to close and the length of rail each side of the gap to de-anchor. The output module also provides the pre-break RNT and L_D. The output module shown in Figure 4 is produced from the input information in Figure 3. The pre-break RNT is estimated at 76ºF. As this is just above the minimum desired RNT of 75ºF, the program gives information to readjust back to the pre-break RNT of 76ºF. The total gap width includes recovering the 3½ inches of rail that was added, and allows for 0.9 inches of anchored track end movement.

In Figure 5, the output information is based on a minimum readjusted RNT being input in Figure 3 as the DRLT of 95ºF rather than 75ºF. To increase the readjusted RNT, the program has solved the total gap width and de-anchoring distance as if the pre-break RNT had been 95ºF and had therefore produced a wider gap and longer influence zone due to a ΔT of 83ºF rather than the actual 64ºF. This means the additional tension needed to close the wider gap will push the RNT higher than the pre-break 76ºF to the desired 95ºF minimum.

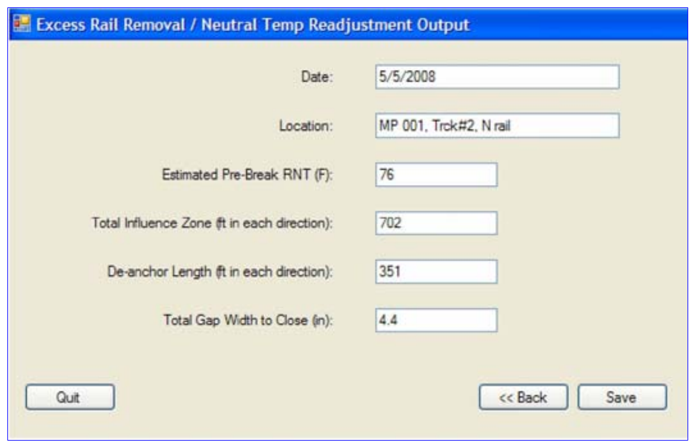

Figure 4. Program Output Based on Figure 3 Input Data

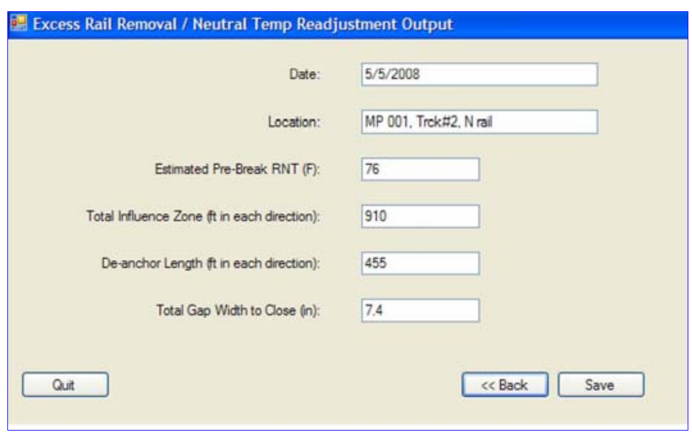

Figure 5. Program Output for Figure 3 Data and Minimum RNT of 95ºF

Application of Readjustment Information

The recommended method of readjustment is to cut the total gap width, de-anchor the required distance, and close the gap width with a puller and/or heat. The higher the rail temperature is at the time of readjustment, without exceeding the pre-break or minimum desired RNT, the less applied tension will be needed to close the gap.

Hot Weather De-Stressing

The hot weather de-stress process is similar to the cold weather readjustment with the exception that the RNT cannot be controlled with gap size. In other words, the readjusted RNT will equal the temperature of the rail at the time of the de-stressing, but the program will provide de-anchoring distance information.

FUTURE WORK

The next step in the development is to refine the program based on railroad requirements and user feedback. As an initial step in this process, a workshop was held in March 2008 in conjunction with the 13th Annual AAR Research Review, Pueblo, Colorado.

REFERENCES

[1] Kish, A. and G. Samavedam, 2005. "Improvements in CWR Destressing for Better Management of Rail Neutral Temperature," *Journal of the Transportation Research Board*, No. 1916, pp. 56-65.

[2] Read, D. and A. Kish. April 2006. "Methodology for More Efficient Continuous Welded Rail Management through Improved De-stressing and Neutral Temperature Readjustment, Part 1 of 2." *Technology Digest* TD-06-010. Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colorado.

[3] Read, D. and A. Kish. April 2006. "Methodology for More Efficient Continuous Welded Rail Management through Improved De-stressing and Neutral Temperature Readjustment, Part 2 of 2." *Technology Digest* TD-06-011. Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colorado.

[4] Read, D. and A. Kish. May 2008. "De-Anchoring Guidelines for Readjustment of Rail Neutral Temperature." *Technology Digest* TD-08-017. Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colorado.