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Methodology for More Efficient CWR Management through Improved De-Stressing and Neutral Temperature Readjustment Part 1 of 2

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Summary

Recent research activity by the Transportation Technology Center, Inc. and Kandrew, Inc. Consulting Services has focused on the development of a new methodology to improve rail neutral temperature readjustment through estimation of the existing neutral temperature and required de-anchor length based on measurable and assumed track parameters.

The effective management of longitudinal thermal forces in continuous welded rail (CWR) is a critical track maintenance issue. Too much compressive forces makes CWR track prone to lateral buckling during hot weather. Conversely, too much tensile force during cold weather can accelerate the growth of rail defects and can cause rail fractures, weld failures, and cause bolted rail joints to pull apart. The magnitude of the thermal force at a given rail temperature is governed by the rail neutral temperature (T_n) at which the net longitudinal force in the rail is zero.

Current railroad procedures require that CWR be installed and maintained within an optimum T_n range to minimize excessive damaging force levels. However, research has shown that the T_n can change over time due to deterioration of track condition and rail maintenance activity, such as broken rail repair. Repairing broken rails and removing rail defects at temperatures below the target T_n require readjustment of the T_n to avoid the potential of buckled track in warmer weather. The difficulty faced by the maintenance personnel is that the readjustment is complicated by not knowing the existing T_n and the length of rail that should be adjusted.

This Technology Digest is the first of two parts presenting an improved methodology for T_n readjustment that allows the track maintainer to estimate the T_n and adjustment length from the rail gap width and the rail temperature at the time the rail is cut or broken. As Part 1, this TD presents critical parameters affecting the readjustment procedure and key relationships that have been developed analytically and verified through tests. Part 2 will demonstrate the application of the methodology to specific T_n readjustment scenarios.



INTRODUCTION

Prevention of excessive longitudinal (thermal) forces in continuous welded rail (CWR) is an important track maintenance and safety issue. Thermal forces are generated when the rail temperature is different from the rail’s neutral temperature – the rail temperature at which the longitudinal force is zero (T_n). Compressive forces are produced when the rail temperature is higher than the T_n and tensile forces are produced with rail temperatures below the T_n . Although tensile forces can accelerate rail defect growth and cause rail joints to fail or pull apart in cold weather, compressive forces tend to be of greater concern due to the potential for track buckling.

Longitudinal forces are controlled by installing and maintaining the rail at T_n levels within specified limits. It is well established, however, that the neutral temperature will vary over time and that the T_n typically shifts to a lower value that can increase the risk of buckling.^{1,2} Low neutral temperatures may be known to exist from rail repair or other maintenance work undertaken during cold weather, or may become apparent during hot weather by wavy or slightly misaligned rail indicating high compressive forces. In either case, the procedure used to readjust or de-stress the rail involves cutting and removing the “excess” rail, de-anchoring a length of rail, elongating the de-anchored rail either mechanically with a rail tensor or thermally with a rail heater, and re-anchoring and welding the rail at the new longitudinal position. The effectiveness of this operation depends on the magnitude of the desired T_n adjustment (how much excess rail is removed) and the length of rail over which the adjustment should be performed. Because

the required T_n adjustment and length of rail to be de-anchored may not be known in the field, the following methodology is being developed to allow a practical estimation of these parameters.

Rail De-Stressing and Readjustment Parameters

In Figure 1, parameters critical to T_n adjustment are described. As shown, the rail is cut or breaks while in tension and the tensile force, which can also be thought of as the difference between the temperature at the time of the break/cut and the neutral rail temperature (ΔT), is released leaving a separation or gap in the rail. The gap width is a function of the ΔT and the longitudinal resistance provided by the fasteners, anchors, ties, and ballast. Also shown is the influence zone (L_d) over which the existing force and neutral temperature levels of the rail are affected by the break/cut. The influence zone length is a function of the longitudinal resistance and ΔT and can be several hundred feet long. If a plug is installed without the rail being adjusted, the gap size becomes the amount of excess rail that is added and the T_n at the gap is reduced to the existing rail temperature at the time the plug is installed. The concept in Figure 1 may also be applied when de-stressing a rail with low T_n that is in compression. In this case, the ΔT is equivalent to the excess rail that must be removed to raise the T_n to the target level.

Although the goal of de-stressing is to raise the existing T_n , its effectiveness may be compromised if the existing T_n and the length of rail requiring adjustment are not known. Currently, there are no verified techniques that are capable of easily and nondestructively measuring T_n under all field

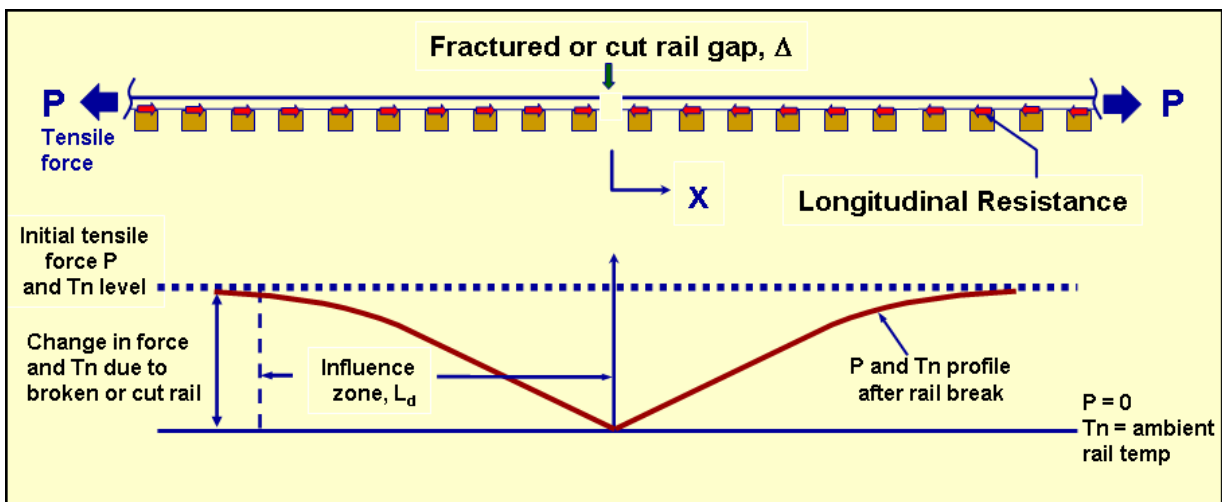


Figure 1. Rail De-Stressing and Readjustment Parameters

conditions. Given this limitation, track maintenance personnel determine the amount of T_n adjustment and the total influence zone ($2L_d$) or the de-anchor length based on judgment and available track time.

Improved De-Stressing Methodology: Key Relationships

Earlier analytic and experimental studies indicated that specific relationships exist between the rail movement (gap size when in tension or movement when in compression), ΔT , and longitudinal resistance. These relationships are shown in Figure 2, where the rail movement is plotted as a function of the ΔT for the range of longitudinal resistance values measured on wood ties with every other tie box anchored (EOTA), wood ties with every tie box anchored, or with elastic fasteners (ETA) and concrete ties with elastic fasteners (CTEF). The dashed line in Figure 2 correlates a 2-inch gap with a ΔT of between 40 and 50°F for EOTA and between 55 and 65°F for ETA and CTEF conditions. The significance of these results is that they enable approximation of the T_n at the time of the rail break/cut which is generally unknown in practice. Figure 2 also shows the T_n variation range, or error band, tends to decrease with smaller gap sizes and increase with larger gap sizes, and that the band width tends to be less for the ETA and CTEF condition compared to the EOTA condition.

As mentioned, the data leading to Figure 2 was obtained in earlier tests at the Transportation

Technology Center (TTC) and provided reasonably good confidence in the predicted relationship between gap size and ΔT for varying longitudinal resistances. More recent measurements have been taken at FAST and under HAL revenue service on the South Morrill subdivision of the Union Pacific Railroad³ to further validate the predicted relationship. As shown in Figure 3, the new test data falls within the earlier analytically determined relationship of Figure 2 and is in excellent agreement with the earlier results.

Figure 4 shows the influence zone length (L_d) as a function of the longitudinal resistance for ΔT values of 30, 60 and 90°F. The tests discussed in references 1 and 2 suggested longitudinal resistance values for the EOTA condition are in the range of 15 to 25 lb/in and the ETA/CTEF condition fall in the range of 25 to 35 lb/in. Further inspection of Figure 4 shows, for example, that for an “average” EOTA condition of 20 lb/in and ΔT of 60°F, the influence zone or de-anchoring length L_d on one side of the cut/break is around 700 feet. Recent test data validating the relationship in Figure 4 is included in Table 1.

Figures 2, 3, and 4 form the basis for a new methodology for improved CWR longitudinal force management through more efficient de-stressing and neutral temperature readjustment. A description and example of how this methodology can be applied to typical T_n readjustment scenarios is included as Part 2 of this digest.

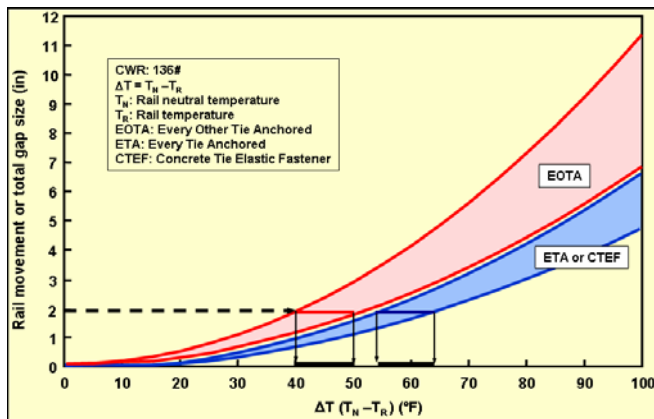


Figure 2. Rail Break Gap Sizes vs. Temperature Differentials for Varying Longitudinal Resistances

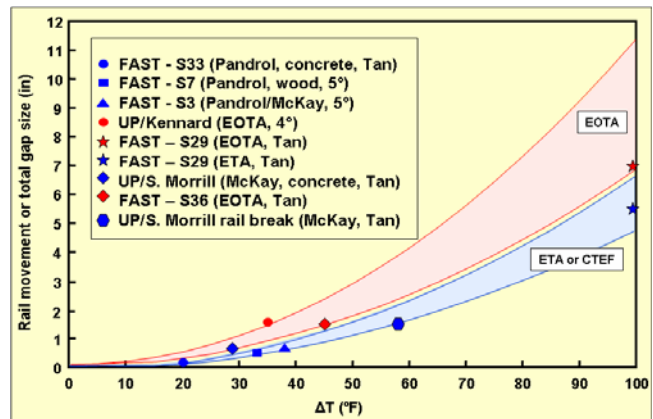


Figure 3. Validation of Rail Gap and ΔT Relationship with Additional Test Data

CONCLUSIONS

A new methodology has been developed for a more efficient readjustment of rail force/neutral temperature in conjunction with winter rail break repair or summer de-stress procedure. The methodology is based on evaluating the unknown T_n to adjust from the rail break gap size or rail cut movement from Figure 2 and the unknown influence zone (length of rail to adjust) from Figure 4. Part 2 will discuss the application aspects of the methodology with an illustrative example of its use.

References

1. A. Kish and G. Samavedam, "Improvements in CWR Destressing for Better Management of Rail

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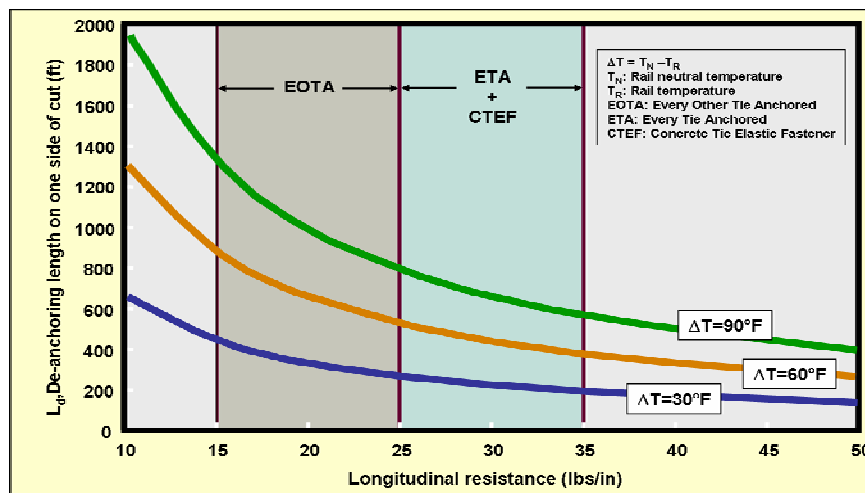


Figure 4. De-anchoring/Unfastening Lengths vs. Longitudinal Resistance for Different Thermal Force Values

Table 1. Comparison of Measured and Theoretical Total Influence Zone Length ($2L_d$) Values for Various Longitudinal Resistances

Test Location	Anchor/Fastener Type/Condition	ΔT	Longitudinal Resistance (lbs/in)	Infl. Zone Measured (ft)	Theoretical Infl. Zone from Figure 4 (ft.)
Sect 36 (10/2005)	EOTA, wood ties, tangent #136 RE, granite ballast, tie/anchor: marginal	45	19	800	1000
UP&S Morrill (10/2005)SR	McKays on tangent, concrete, #133 RE, granite ballast: just surfaced	27	27	440	430
UP&S Morrill (10/2005)NR	McKays on tangent, concrete, #133 RE, granite ballast: just surfaced	31	24	540	560
Sect 29 (3/2004)	EOTA, wood ties, tangent, #136 RE, granite ballast, tie/anchor: good	100	21	1800	2000
Sect 29 (3/2004)	ETA, wood ties, tangent, #136 RE, granite ballast, tie/anchor: good	100	31	1320	1400

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