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Cold Weather Rail Break and Rail Re-Stressing Simulation Tests

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Summary

Rail breaks can occur during cold weather when the rail temperature is well below the neutral temperature (T_N), and tensile forces are high. Repair of such breaks often adds rail to the track, lowering the neutral temperature. If not corrected, the potential for buckled track in hot weather will be increased.

Tests were performed in both March and November 2004 by the Transportation Technology Center, Inc., (TTCI) to simulate the effect of cold weather rail breaks and subsequent repair and rail stressing procedures on the rail neutral temperature behavior of continuous welded rail (CWR). The test results indicate that the two rail re-stressing procedures evaluated were only partially effective at restoring the pre-rail break neutral temperature. The effect of traffic following the re-stressing had a significant influence on the neutral temperature performance.

Two typical re-stressing procedures were evaluated in full scale track tests at the Facility for Accelerated Service Testing (FAST). In both tests, a cold weather rail break was simulated by cutting the rail in the center of the test zone with the rail temperature approximately 100° F below the neutral temperature. In Test 1, the neutral temperature was adjusted by pulling the rail with a rail puller to restore the pre-cut tension level without removing rail anchors in the test zone. In Test 2, the tension was restored by pulling rail that was de-anchored 200-feet on each side of the cut.

Test results showed that both methods were effective in raising the neutral temperature of the rail. The adjusted neutral temperature was closest to the target neutral temperature at the time and location of the rail pull. The accumulation of tonnage following both tests tended to equalize the neutral temperature along the zone, and caused an overall reduction in the neutral temperature.

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INTRODUCTION

Maintaining the rail neutral temperature within limits that prevent damaging thermal forces is critical to the safe and efficient operation of CWR track. Neutral temperature is known to vary over time due to a variety of reasons including the effects of track maintenance. Repairing broken rails during cold weather when the ambient rail temperature is well below the neutral temperature and significant rail tensile forces are present creates the potential of significantly lowering the neutral temperature in the vicinity of the rail break. The lower neutral temperature will create a potential for track buckling if the rail is not adjusted before the onset of hot weather.

All railroads have developed maintenance procedures to adjust the neutral temperature by re-stressing the rail after a disturbance. These re-stressing procedures are designed to lengthen the rail to its original (pre-break) longitudinal position by either stretching with a hydraulic puller or heating and allowing the rail to expand. This process is intended to remove the excess rail produced by the loss of tension during the rail break. The amount of excess rail is equivalent to the width of the rail gap at the time of the break.

Often, it is difficult to re-stress the rail immediately following a break due to low temperatures and wide gaps. In such cases, a temporary rail plug is installed with bolted joints as the initial repair technique. The rail is then re-stressed later under more favorable temperatures and gap conditions but before the start of hot weather. Assuming this to be typical North American practice, TTCI performed two tests to measure the neutral temperature response to a cold weather rail break and to the subsequent rail re-stressing procedure. The purpose of the testing was to address the following issues:

- What distance from the rail break is the existing neutral temperature profile affected by the release of the tensile load in the rail?
- What is the neutral temperature profile following the re-stressing operation?
- How effective is the rail puller at restoring the neutral temperature?
- What is the effect on the post adjustment neutral temperature profile of re-stressing with and without de-anchoring the rail?
- If rail anchors are removed, what is the optimum length to de-anchor?
- What are the effects of traffic on the adjusted neutral temperature?

DESCRIPTION OF TESTS

The tests were performed in Section 29 of the FAST High Tonnage Loop (HTL). The test zone was configured as follows:

- 1,000-foot long tangent
- Wood ties on 19.5-inch centers, spikes, and drive-on rail anchors
- 136 RE welded rail

Every tie in one half of the zone was boxed anchored to simulate the longitudinal resistance of concrete tie track and every other tie was box anchored in the other half as typical wood tie track.

Longitudinal rail force and rail temperature were measured with strain gages and thermocouples distributed along the test zone length as shown in Figure 1. The data was collected with a data logger and neutral temperature was calculated from the measured parameters.

Two tests were performed in 2004. Test 1 was performed in March and Test 2 in November. In both tests, the rail throughout the length of the test zone (outside rail in March and inside rail in November) was de-stressed to a target neutral temperature of 125° F. The rail was then cut at approximately 20° F rail temperature to simulate a cold weather rail break. A rail plug was installed a few hours after the rail was cut with bolted joints as a temporary repair. The rail was then re-stressed several days later at a warmer rail temperature using a rail puller and the plug field welded in place with thermite welds.

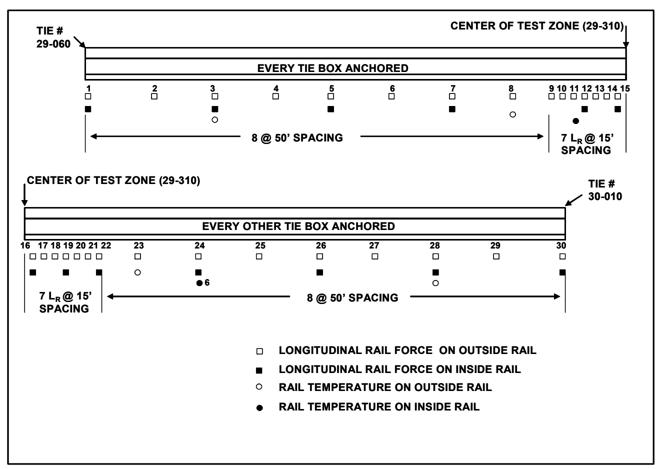

Figure 1: Layout of Rail Force and Temperature Measurements in the Test Zone

The re-stressing procedure that was followed in each test is described below:

- Test 1 – re-stressing without de-anchoring. One end of the plug was welded without adjustment at a rail temperature of about 60° F. The gap at the closure weld was then cut to 2.75 inches with the rail temperature at 70° F and the rail puller installed. The rail was pulled to close the gap to the nominal 1-inch required for welding and the weld poured with the rail at 75° F. The rail was pulled without removal of rail anchors.
- Test 2 – re-stressing by de-anchoring 200-feet of rail each side of the cut. As in Test 1, one end of the plug was welded without prior adjustment. The rail was cut to produce a 5-inch gap and then de-anchored 200-feet on each side of the closure weld with the rail temperature at 57° F. The puller was installed and began pulling with the rail at 78° F and the gap at 2.3 inches. The closure weld was then poured with the rail at 81° F. It is important to note that with this method, the amount of rail removed was based on restoring the 400-feet of free rail to the initial neutral temperature.

A summary of the test parameters is shown in Table 1. Included in the Table is rail location, nominal initial (pre-cut) neutral temperature, rail temperature and tensile force level in the rail at the time the rail was cut, the gap after cutting, the rail temperature and gap at the time of the final rail adjustment and the re-stressing method for each test.

Test	1	2
Rail	Outside	Inside
Initial T_N	125°F	125°F
Rail Cut Temp	19 °F	21°F
Tensile Force Level	230 – 250 klb	250 – 270 klb
Gap (inches)	5.6 inches	6.7 inches
Temp and Gap[1] At Re-Stressing	70°F/ 2.75 inches	78°F/ 2.30 inches
Re-Stress Method	Rail puller without anchor removal	Rail puller and removal of anchors 200 feet each side of cut

Table 1: Test Parameter Summary

TEST RESULTS

The test results are presented in plots of the rail neutral temperature as a function of distance from the rail cut at the center of the testing zone during each test.

Test 1

In Figure 2, five sets of T_N data collected from the outside rail during Test 1 are plotted, including the initial pre-cut T_N profile in the test zone, the T_N profile immediately following the rail cut, the T_N profile following the rail stressing procedure, the T_N profile after accumulation of 3.5 million gross tons (MGT) of FAST 39-ton axle load traffic following re-stressing, and the profile after 24 MGT of traffic.

Test 1 data indicates that:

1. The initial neutral temperate in the test zone was relatively uniform around 125° F.
2. The T_N response following the rail cut was clear showing a reduction at the rail cut location to the ambient 20° F temperature. The reduction of the existing T_N away from the zone center was less severe on the every tie anchored half of the zone. However, the influence of the rail break in terms of lowering the T_N exceeded 500-feet on both halves of the zone.
3. The re-stressing procedure was effective at restoring the pre-cut T_N within about 100-feet of the zone center, but the effectiveness was reduced further away from the pull location.

In Test 1, the effects of traffic were significant following the re-stressing causing equalization and lowering of the T_N profile across the zone.

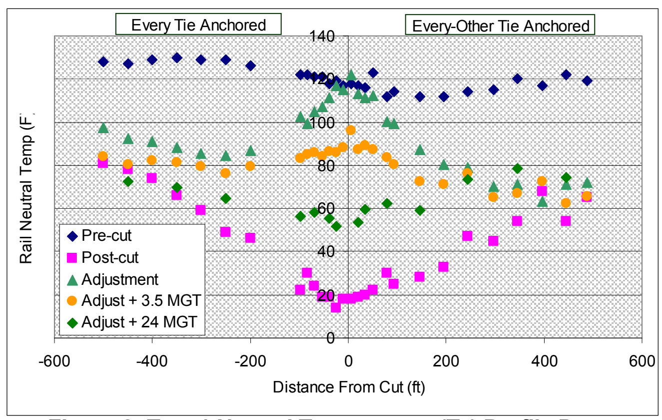

Figure 2: Test 1 Neutral Temperature (T_N) Profile Data

Test 2

A similar plot from data collected in Test 2 is included as Figure 3. Once again, the initial pre-cut T_N profile, the T_N profile immediately following the rail cut, the T_N profile following the rail stressing procedure, and the T_N profile after accumulation of 3 MGT of traffic following re-stressing is plotted.

[1] Gap width includes 1 inch for thermite weld

The pre and post cut data in Test 2 is similar to that in Test 1. However, there is a noticeable difference in the neutral temperature profile following the re-stressing procedure in Test 2 (de-anchoring 200-feet each side of the cut) compared to the procedure in Test 1 (no de-anchoring). As might be expected, removal of rail anchors produced a more uniform profile in Test 2, although the final T_N values were well below the target of 125°F. More importantly, however, is the effect traffic has in lowering the neutral temperature in the center half of the zone which was similar to Test 1.

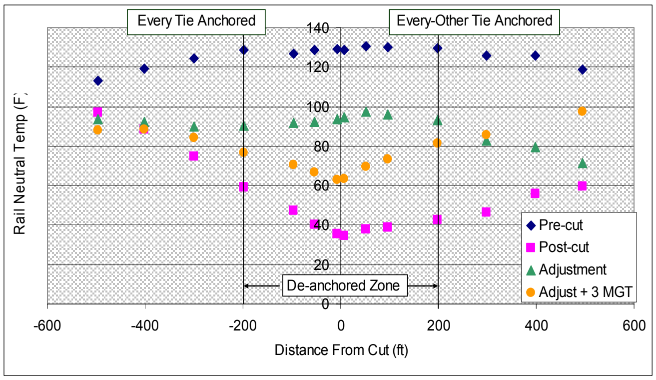

Figure 3: Test 2 Neutral Temperature Profile Data

CONCLUSIONS

1. The results of both re-stressing methods were temporary as traffic accumulation significantly reduced the re-stressed rail neutral temperature in the center half of the test zone. The T_N following re-stressing without removing anchors dropped by approximately 30° F after 3.5 MGT and by 40°F after 24 MGT. The T_N also dropped by about 30°F at 3-MGT following re-stressing in which the rail was de-anchored for 200-feet each side of the center.

2. Re-stressing by pulling the rail to close a 1.75-inch gap without removing rail anchors produced an uneven neutral temperature profile. Although this technique produced the desired neutral temperature at the pull point, the T_N was about 20°F lower than the target temperature 100-feet away from the center and about 40°F lower some 300-feet away.

3. The post adjustment T_N without de-anchoring was more uniform in the high longitudinal half of the zone.

4. Re-stressing by pulling the rail to close a 1.3-inch gap with 200-feet of rail de-anchored on each side of the pull point produced a fairly uniform T_N that was about 20°F below the initial temperature. Lower than desired neutral temperature was due to the test procedure calling for adjustment of 400-feet of rail to a 125°F T_N rather than elimination of the post-cut gap. However, the neutral temperature profile was uniform across the 400-feet that were de-anchored in contrast to the uneven neutral temperature profile created without removing anchors.

5. In both tests, the influence on existing neutral temperature following the release of roughly 250,000 pounds of tension exceeded 500-feet on each side of the cut. The length of affected rail was less on the half zone side with every tie anchored due to the higher longitudinal stiffness. Rail movement through the rail anchors was noted in both sides of the cut and following the rail cutting during both tests.

FUTURE WORK

The tests described have produced valuable data regarding rail neutral temperature behavior. The surprising result has been the magnitude of the traffic effect on the re-stressed neutral temperature profile. Unfortunately, careful measurements of rail longitudinal displacement were not performed and the cause of the traffic effect was not quantified. Future tests are planned for 2005 at FAST and in revenue service to further evaluate and define the mechanism.

ACKNOWLEDGEMENTS

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