Methods and Procedures for Laying and Maintaining Continuous Welded Rail To Attain Lateral Track Stability

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Lateral track stability is attained by proper methods and procedures for laying and maintaining continuous welded rail (CWR). CWR must be anchored at or adjusted for a rail temperature of 95°F or higher either by mechanical heating or by natural temperatures. After CWR has been installed, it should not be raised or disturbed at rail temperatures higher than the anchored or adjusted rail temperature except when necessary precautions are taken. If the track buckles while it is being worked because of expansion due to temperature, it must be cut, adjusted, and properly tamped. When thermite welding is performed, a defective rail is changed, or a plug is installed, precautions must be taken to not add rail to the track. Additional rail creates undesirable compressive forces when increased temperatures cause elongation of the rail. The proper methods and procedures to attain lateral stability have been generated from the use of CWR in track for the past 30 years.

Consolidated Rail Corporation (Conrail) was made up of several Northeast railroads on April 1, 1976. Each railroad had its own policies and procedures for performing track maintenance. Continuous welded rail (CWR) has been in track on the railroad for more than 30 years. An attempt will be made to point out what has been done through the years to arrive at present methods and procedures.

In the early years CWR was not heated, and it was not laid if the temperature was below 40°F. Thus, rail was only laid between April 1 and October 31. It was thought that if the rail was laid at temperatures between 60° and 80°F, no later adjustment to compensate for temperature would have to be made unless the need was clearly demonstrated by some condition in the track. Buffer rails were used at the ends of full-length strings to allow for some contraction and expansion. When the rail was laid at temperatures below 60°F, it was necessary to readjust and install a shorter buffer rail during the first hot weather spell. Likewise if the CWR was laid and anchored at a temperature greater than 80°F, the buffer rail would have to be readjusted during cooler weather. As can be seen in many cases, buffer rails were being changed in the spring and fall because of the inability to lay or maintain rail at the mean temperature.

When buffer rails were not used and the rail temperature was over 80°F, the rail was laid in compression by bumping; when the rail temperature was 60°F and under, the rail was laid in tension by pulling. As can be seen in the initial rail laying procedures, there was very little control over temperature, and if the rail was not laid in the 60° to 80°F range, other precautions had to be taken. As the number of miles of CWR increased, it became very difficult and costly to continue to readjust and change buffer rails. In the mid 1960s it became apparent that for proper installation and maintenance rail had to be mechanically heated to a desired uniform temperature, which was accomplished by introducing heat from one end of each string to the other in the direction of rail laying. The number of inches that the string was to be expanded for the rise in temperature was calculated and the gap was set for the expansion and closed. This also allowed both rails to be anchored at the same temperature, which is a significant factor in preventing buckled track.

A pull-apart caused by a drop in temperature was considered more tolerable than buckled track caused by a rise in temperature. A train has a much better chance of traveling over a pull-apart than buckled track without derailing, so it was determined that when the CWR was heated, it was to be anchored at 85°F. Also, signal systems give protection when pull-aparts occur that interrupt the track circuit. In the late 1960s CWR strings were field-welded together, which, because of the elimination of bolted joints, reduced the potential for pull-aparts.

In the early years CWR was not disturbed for maintenance work in the months of July and August, but as the amount of CWR in track increased, maintenance became necessary regardless of the temperature. In the mid-1960s, when the air temperature exceeded 80°F, the track was worked during the early morning hours and protected by a temporary 30-mph slow order until the rail cooled in the evening. When it became necessary to work CWR in warm weather months, proper precautions had to be taken, such as the following:

- A full ballast section had to be maintained at all times.
- When ties were installed, the ballast removed from the tie ends had to be kept to a minimum and backfilled every night.
- During tie installation the track raise was kept to a minimum; both rails were raised simultaneously and a crosslevel was maintained at all times.
- Anchors removed for tie installation were reinstalled immediately after spiking.
- When the track was raised for surfacing, the raise was kept to a minimum, both rails were raised simultaneously, and a crosslevel was maintained at all times.
- When track was tied and not tamped, the first train was restricted to 30 mph, and the track was inspected by the track supervisor before the slow order was lifted.

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- All cribs were filled completely the day the track was tamped, and final dress was completed as soon as possible.
- The final ballast section required all cribs to be full to the top of the tie and at least 12 in. beyond the end of tie before sloping off to the subgrade.

Experience had shown that a track that is shy of ballast in the cribs or that was raised excessively had a definite tendency to kick out or buckle. Also, rail in embankment cuts retains more heat than rail on fills where the air is free to circulate. All such locations of restricted air circulation were observed closely during periods of high temperature. Many of the these procedures are still followed today.

Through the years of working CWR in warm weather, maintenance engineers have encountered problems with lateral stability at the ends of restrained areas such as road crossing, bridges, station platforms, turnouts, and the like. In the mid-1970s it was decided to heat and anchor the rail to 95°F. Pull-aparts had been successfully eliminated by field welding, but the railroad was still experiencing some trouble with buckled track.

Experience has also shown that if a track buckles, it must be cut and readjusted because it is likely to buckle again if it is not adjusted properly. Work crews tend to realign the buckled portion without cutting the rail, a procedure that is not tolerated. Readjusting the rail by cutting out the buckled portion has reduced the potential for buckling.

In the early days of Conrail, CWR use was restricted on curves of more than 6 degrees. This instruction was later changed to allow the use of CWR on all curves, but they were monitored for any indications of movement up and out of the plates. If tipping occurred, the rail expansion was adjusted and base clips were installed to prevent overturning. During the last few years, due to types of traffic and tonnage, problems have been experienced with CWR overturning on curves. Elastic-type fasteners on lines with severe curvature, grades, and tonnage are now being installed.

Track patrols are conducted 7 days a week when the air temperature is above 90°F or below 20°F. The patrols are operated at the discretion of the division engineer. Instructions for laying and maintaining CWR are uniform over the system because there is no significant temperature variation across the railroad to warrant different instructions for each specific area.

There have been problems with self-jacking lining tampers when track is surfaced on curves in cold weather. There is a tendency to line curves to the inside because it is the path of least resistance. This happens without the operator's knowledge unless reference points are established and monitored to ensure that the curve is not being lined to the inside. Production gangs are normally shut down from late October or early November until early April, which helps alleviate some of the problem of curves being lined to the inside. If curves must be worked in cold weather, reference points must be established to ensure that the curve is not lined exclusively to the inside.

Methods and procedures have been adopted during the past 30 years to reduce the potential for buckled track during work on CWR under various temperature ranges. The procedures have helped reduce the amount of buckling but incidents still occur where there are curves, grades, and helper units. These incidents are caused by improper train handling and not the track. Precautions are taken by placing slow orders on newly worked CWR track so that the braking of the train will not affect the unstable track.

Incorporated in training schools and seminars for supervisors is a review of the methods and procedures for maintenance on CWR. Because of problems with buckled track through the years, supervisors are made aware of the consequences of failure to follow procedures. Each time a derailment occurs because of buckled track, maintenance methods and procedures are evaluated to see if they are adequate for present-day operation.

Lateral track stability is attained by following proper methods and procedures for laying and maintaining CWR. Conrail's present methods and procedures are outlined in this paper.

Lateral track stability starts with the proper rail laying procedures. CWR must be anchored at or adjusted for a rail temperature of 95°F or higher. When the rail temperature is lower than 95°F, a heating device is used for expanding the CWR to make the proper adjustment. When CWR has been anchored at a temperature below 95°F and not adjusted for temperature during the rail laying operation, it should be adjusted as soon as weather conditions have brought the rail to a temperature of 95°F or higher. The anchored rail temperature and length of adjustment must be recorded and retained for future reference when the involved stretch of rail is worked.

ADJUSTMENT BY MECHANICAL HEATING

Rail may be expanded after it has been laid in the tie plates and before or after spiking, but it must be expanded before it is anchored. CWR should be heated so that the expansion is introduced from one end of each string to the other in the direction of rail laying. The number of inches by which each CWR string should be expanded during the rail laying operation may be determined by calculation or from an existing table (see Figure 1). A gap equal to the amount of expansion needed for each string of CWR should be provided between the end of that string and the end of the next adjacent string. A minimum of 10 ties should be box anchored on the near end of the adjacent string to hold the string in place and to avoid closing the expansion gap in the reverse direction, which would improperly adjust the string being heated. Heating should start at the beginning of the first CWR string and be applied steadily until the required expansion has been obtained at the end of the string. Uniformity of expansion is to be controlled by marking each quarter of the string and introducing expansion as follows:

- Quarter point: one-fourth of total required expansion,
- Half-point: half of total required expansion, and
- Three-fourths point: three-fourths of total required expansion.

Quarter points should be marked on the rail and the tie plate to ensure that the amount of expansion is accurately determined. The tie plate used as a reference point must be one that is spiked, so that it will not move as rail expands. If

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CONSOLIDATED RAIL CORPORATION
CONTINUOUS WELDED RAIL
RECORD OF RAIL LAYING

Region _____ Division _____ Line _____

Date _____

Table for Adjustment of CWR For Temperature Change

Measured CWR Temperature	Length of CWR in Feet					
	950′—1049′	1050′—1149′	1150′—1249′	1250′—1349′	1350′—1449′	1450′—1550′
111—120	+2	+2	+2	+2	+2	+2
101—110	+1	+1	+1	+1	+1	+1
90—100	0	0	0	0	0	0
80—89	1	1	1	1	1	1
70—79	2	2	2	2	2	2
60—69	2	3	3	3	3	4
50—59	3	3	4	4	4	5
40—49	4	4	5	5	5	6
30—39	5	5	6	6	7	7
20—29	5	6	7	7	8	8
10—19	6	7	7	8	9	9
0—9	7	8	8	9	10	11
-10—-1	8	9	9	10	11	12
-20—-11	9	9	10	11	12	13

NOTE: All adjustment figures are in inches.
In the event temperature or lengths do not fall within table coverage,
Local Supervisor will compute adjustment in compliance with
Paragraph 119.5, MW-4, dated March 1, 1977.

Rail Record

String No.	Track No.	E or N W or S	Rail	M.P. From	M.P. To	Rail Temp.	Adjustment From Table	Quarter Point Adj. 1st	2nd	3rd
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

Signed _____

Title _____

FIGURE 1 Conrail record of rail laying for CWR.

the first half of the heated CWR string does not have the required expansion at each quarter point, the heater will back over the heated portion without applying heat and then reheat the rail until the necessary expansion is obtained. As heating progresses, a minimum of 1 anchor per 39 ft of rail should be applied on the side of the tie that will prevent the rail from losing expansion. At the end of the completely expanded string, a minimum of 10 ties should be box anchored immediately after the gap is closed to hold the expansion. The entire CWR is to be anchored as described or per standards before trains are permitted to operate over it at timetable speeds. CWR is to be anchored in both directions by box anchoring as follows.

Every Tie (Full Boxing)

In the following areas, every tie is box anchored:

- Curves of 3 degrees and more;
- At each bolted end of a CWR string for 200 ft, except where CWR strings are butt-welded together in the field, in which case every other tie is box anchored;
- Adjacent to each side of track crossings for 200 ft;
- Adjacent to each side of open floor bridges for 200 ft;
- Adjacent to each side of public and private road crossings for 200 ft;
- Through turnouts laid with CWR to the extent practicable, and for 200 ft adjacent to switch ties and each end of turnouts through which CWR extends; and
- Through CWR strings less than 400 ft long.

Every Other Tie

In the following areas, every other tie is box anchored:

- Through the remainder of each CWR string where full boxing is not specified above; and
- Across open floor decks on timber and steel structures where blocking has been placed between bridge ties and the deck is properly fastened with hook bolts.

ADJUSTMENT BY NATURAL TEMPERATURE

When it is necessary to adjust CWR already in track, the required increase or decrease may be found by taking the difference between the desired and the recorded temperature of each string of CWR and calculating the amount of adjustment or by using an existing table. All rail anchors must be removed from strings of CWR requiring adjustment to permit the desired expansion or contraction. Tie plates should be tapped with a hammer or mechanical device to free the rail. All rail anchors must be reapplied immediately after the desired change in rail length has been obtained. Where numerous strings need adjustment, it is desirable to make adjustments for three or four strings at a time, if possible. For this purpose, a rail cut should be made near the center of the adjusted area. When adjoining CWR strings are connected directly by a bolted rail joint, the adjustment for either compression or tension should be made by cutting out the drilled end of each CWR and field welding in a rail of required length. Where CWR strings are field butt-welded together, the adjustment may be made by cutting and butt welding in a piece of rail.

REPLACEMENT OF DEFECTIVE RAIL OR WELD

In order to avoid addition of rail when thermite welding is performed, a defective rail is changed, or a plug is installed, the following procedure must be used if the rail temperature is less than 95°F. During thermite welding, the required gap must always be obtained by cropping the ends of the rail and the gap maintained by using a rail stretcher, if necessary. When a defective rail is changed or a plug is installed, the length of rail to be replaced must be measured before removal and the piece to be installed cut to the same length. The gap that remains after installing the piece of rail must be closed by heating.

PROCEDURES FOR MAINTAINING AND WORKING CWR TRACK

After CWR has been laid and adjusted, proper maintenance procedures must be followed to ensure lateral stability of the track. The track should not be raised or otherwise disturbed at rail temperatures higher than its installation or adjusted rail temperature except when the necessary precautions are taken. The following work should not be performed unless measures are taken to protect the track.

- Out-of-face track raising,
- Heavy tie renewals (with or without raising),
- Extensive lining or disturbing of the ballast section, and
- Smoothing or lining where more than five consecutive ties are loosened from their tie beds or where more than five consecutive or intermittent ties are loosened from their tie beds in any 39-ft length of track.

Rail Temperature Equal to or Below Installation or Adjusted Temperature

The following requirements apply to maintenance performed on track whose rail temperature is no higher than the installation temperature or the latest adjusted rail temperature:

- When CWR track is raised, the height of the raise should be kept to the minimum necessary to obtain a good surface but should not exceed 1½ in. If a higher raise is needed to meet a required profile, additional raises should be made with enough elapsed time between raises for the track to become sufficiently settled by the passage of trains to ensure stability at timetable speed. If the track is undercut, the above will not apply if the rail is cut and adjusted.
- Both rails should be raised simultaneously in CWR track, and a crosslevel should be maintained at all times. Raising without immediately and fully tamping all ties should be avoided.

- When ties are renewed, no more than three consecutive ties or eight ties per 39-ft section of rail should be renewed in any one pass. If more ties need to be renewed, additional passes should be made.
- Before track is returned to normal service, all ties installed should be rail spiked and tamped; rail anchors should be reapplied and standard ballast section restored. A standard ballast section for CWR should be all cribs full to the top of the tie, 12 in. of ballast straight out from the end of the tie, and a 2:1 slope to the sub-ballast line.
- The temperature at which the rail is worked should be recorded, but should not be considered as the adjusted temperature.
- An appropriate slow order, not to exceed 30 mph, should be placed on all track worked that day. The slow order should remain in effect for 24 hr and until 50,000 gross tons of traffic has passed over the work area. The division engineer should determine through the dispatcher when the minimum tonnage has run over the work area and make arrangements for inspection of the track and a possible increase in speed. If an inspection of the work area reveals no exceptions, the speed of the track should be upgraded to timetable speed.

Rail Temperature Higher Than Installation or Adjusted Temperature

If the measured rail temperature is higher than the installation or the latest adjusted rail temperature, the following procedures apply to the adjustment of CWR before or during maintenance operations:

- The ends of CWR strings out of the tie plates should be disconnected or cut and lined to clear adjoining rail ends.
- All anchors should be removed from the area to be adjusted.
- After the track has been raised, tamped, and lined, rail closures should be made and the CWR adjusted as needed.
- All rail anchors should be reapplied to prescribed standards before the track is returned to normal service.
- A standard ballast section should be restored before the track is returned to normal service.
- In the event work is performed through only part of a CWR string, the entire string should be freed, and the unworked portion of the string should be loosened in its tie plates by operating a heavy self-propelled unit of maintenance-of-way equipment over the unworked portion or tapping the tie plates with a hammer before closure and anchoring.
- The rail temperature of each CWR string that is adjusted should be measured and recorded.
- If the rail is adjusted before or during the maintenance operation, as outlined above, the track may be placed in service with an appropriate slow order not to exceed 30 mph on all track worked that day. The slow order should remain in effect for 24 hr and until 50,000 gross tons of traffic has passed over the work area. The division engineer should determine through the dispatcher when the minimum tonnage has been run over the work area and then make arrangements for inspection of the track and possible increase in speed. If an inspection of the work area reveals no exceptions, the speed of the track should be upgraded to timetable speed.
- If the rail is not adjusted before or during the maintenance operation, a 10 mph slow order should be placed on the work area when the track is returned to service, and the track should be inspected after the first train.
- The 10-mph slow order should remain in effect for 24 hr and until 50,000 gross tons of traffic has passed over the work area. Provided no exceptions are taken after inspection, the order should be upgraded to 30 mph, which should remain in effect another 48 hr and until another 50,000 gross tons of traffic has passed over the work area. The division engineer should determine through the dispatcher when the minimum tonnage has been run over the work area and should then make arrangements for inspection of the track and a possible increase in speed. If inspection reveals no exceptions, the work area should be upgraded to timetable speed.
- When the latest adjusted temperature is unknown and the existing rail temperature is 80°F or above, the instructions for performing work when the rail temperature is higher than the installation or adjusted temperature should apply.

Slow Orders for Track Stabilized by Dynamic Track Stabilizer

Instructions for newly surfaced CWR track that has been stabilized by a dynamic track stabilizer immediately after the surfacing operation are as follows:

- The track should be inspected by the gang supervisor before being returned to service.
- A slow order of 10 mph should be placed on the work area for the first train, or at least 5,000 gross tons of traffic.
- After reinspection of the track, a slow order of 30 mph should be placed on the work area for at least one train, or at least 5,000 gross tons of traffic.
- After another reinspection, a slow order of 50 mph should be placed on the work area for at least one train, or at least 5,000 gross tons of traffic.
- The track should be returned to service at timetable speed after a third reinspection.

Maintenance of Buckled Track

If the track buckles while it is being worked because of expansion caused by temperature, it must be cut, adjusted, and properly tamped using the following procedures:

- Both rails should be cut with a torch at the location of maximum displacement after the track has been lined sufficiently to ensure that all pressure has been removed and to prevent the track from reacting rapidly when it is cut. If the displaced area is near a joint, the joint bars should be removed.
- The cut or uncoupled rails should be aligned, allowing the ends to bypass.
- In order to ensure that the expansion is made uniformly throughout the rail being adjusted, the rails should be marked at 330, 660, and 990 ft from the location where the rail ends are bypassed.

- All anchors should be removed for ¼ mi (1,320 ft) from each side of the location at which the rails have been bypassed in order to properly adjust the rail.
- If the rail temperature is over 95°F, the rail adjustment can be completed. The expansion should be uniformly distributed throughout the 1,320 ft of rail. The distribution can be determined by noting the amount of rail movement at the previously marked locations at 330, 660, and 990 ft from the bypassed ends. Particular attention should be paid to ensure that the rail does not bind on tie plates, spikes, or other obstructions. The tie plates should be tapped as necessary to obtain free rail movement.
- After proper expansion has been attained throughout the 1,320-ft rail, the anchors should be reapplied. The application of anchors should start at the point 1,320 ft from the location where the rails are bypassed and work toward that area. Each point marked on the rail should be checked to ensure that the expansion is being made uniformly throughout the rail. All anchors should be reapplied properly and installed tightly against the ties.
- If the rail temperature is under 95°F, the rail should be heated to obtain the proper adjustment. The procedures to be followed are the same as those outlined for adjusting the rail when the temperature is over 95°F. The rail should be heated from the point 1,320 ft from where the rails are bypassed, and the anchors should be reapplied to hold the expansion as the heater moves toward the rail bypass point. Care should be exercised to ensure that the rail is heated to a minimum of 95°F before the anchors are reapplied.

If the rail temperature is less than 95°F and it is not possible to adjust it immediately to that temperature by heating, the following procedures should be followed:

- The rail should be cut or the splice bars removed at the location of maximum displacement after the track has been lined as necessary to ensure that all pressure has been removed.
- Track and bypass rail ends should be aligned.
- All rail anchors should be removed for 1,320 ft and the expansion should be adjusted, making certain that the rail does not bind on tie plates, spikes, and the like.
- After rail expansion has been adjusted evenly throughout the 1,320 ft, the anchors should be reapplied, making sure that they are all tight against the ties.
- The track should be lined back to proper locations and additional cuts made on the rail as necessary.
- The area adjusted should be protected by a maximum 10-mph slow order until the rail expansion is adjusted to 95°F with or without heating.

A new heat record will be prepared with the new adjusted temperature. It should also be noted on the record that the adjustment was made by use of a heater or by natural temperature change and also that all anchors were removed in order to make the adjustments.

SUMMARY

Conrail's practices and procedures for laying and maintaining CWR have achieved the desired results, but have created problems such as loss of production by gangs working CWR during times of high rail temperature and delay of train traffic while tonnage and time requirements have been satisfied. Despite these problems, Conrail has been successful in eliminating buckled track incidents by following the methods and procedures outlined in this paper.