Effectiveness of Southern Pacific Lines in Controlling the Behavior of Continuous Welded Rail Track

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The recent efforts of Southern Pacific Lines in controlling the behavior of continuous welded rail are presented. The three principal causes of track buckling are presented, and standards, instructions, rules, and procedures in effect on Southern Pacific Lines that are used to prevent track buckling are discussed in detail. Southern Pacific Lines' training programs for maintenance-of-way employees and locomotive engineers in preventing track buckling are also presented. Also included in the paper are the chief engineer's instructions on track maintenance to protect against lateral track movement, track buckling, and pull-aparts and Operating Rule 465, Train Handling over Disturbed Track.

The number of track buckling incidents on the Southern Pacific Lines has decreased steadily over the past 6 years even though the total miles of continuous welded rail (CWR) are increasing, as are the average tons per train and the average speed per train. The knowledge learned from experience, from other railroads, and from track research in the United States has resulted in this successful performance.

Southern Pacific recognized early the advantages of CWR and since 1956 has replaced jointed rail with new and cascaded second-hand rail in the highly diversified main lines and other tracks. The lines traverse granite mountains; hot, arid deserts; and humid, marshy swamps. The geometry of the track includes 15-degree curves and 3.5 percent grades. Tracks run through areas where record snowfalls occur and areas that receive the greatest and least amounts of rainfall. Ambient temperatures produce rail temperatures on the Southern Pacific Lines from a high of 156°F to a low of −50°F. CWR is used in all these areas.

A great deal has been learned over the years about how CWR must be laid and maintained. The instructions, procedures, and track standards of Southern Pacific Lines have changed as it has been learned how to better maintain lateral track stability. These instructions are detailed in the chief engineer's instructions for the maintenance-of-way and structures.

Track buckling is the formation of lateral misalignments caused by any one or a combination of the following:

- High compressive forces caused by thermal loads and low neutral temperatures,
- Weakened track conditions due to low track resistance or alignment deviations, and
- Vehicle loads.

The manner in which each of these three causes of track buckling has been addressed is the largest factor that has helped avoid track buckling on the Southern Pacific Lines. These factors are detailed in the chief engineer's instructions, specifically Section 2.8, Track Maintenance Procedures Required for Protection Against Lateral Movement of Track, Track Buckling and Pull Aparts, and Section 2.9, Maintenance of Continuous Welded Rail. Copies of the chief engineer's instructions are available from the author on request.

HIGH COMPRESSIVE FORCES

High compressive forces caused by thermal loads and low neutral temperatures must be prevented by laying CWR at or above the required neutral rail temperature, maintaining that minimum neutral rail temperature, and maintaining track to the required common standards.

Instructions to maintenance employees include a zone map of the Southern Pacific system that specifies the minimum neutral rail temperatures allowed for each geographic area of the system (Figure 1). Neutral temperature is defined as the rail temperature at which the net longitudinal force due to thermal stress is zero and the rail is under neither tension nor compression. Minimum neutral rail temperature is defined as the lowest rail temperature to which CWR is installed and maintained. The minimum neutral rail temperature on the Southern Pacific Lines varies between 90° and 120°F. This temperature was originally based on the following equation:

$$\mathrm{ART} = \frac{(2.1TH + TL)}{3} \qquad (1)$$

where

ART = adjusted rail temperature,
TH = highest rail temperature expected locally, and
TL = lowest rail temperature expected locally. (In areas subject to extreme low temperatures, the average low temperature is used instead of the lowest temperature.)

However, during 1988, in certain areas of the system, the minimum neutral temperature was adjusted upward to provide additional protection against track buckling.

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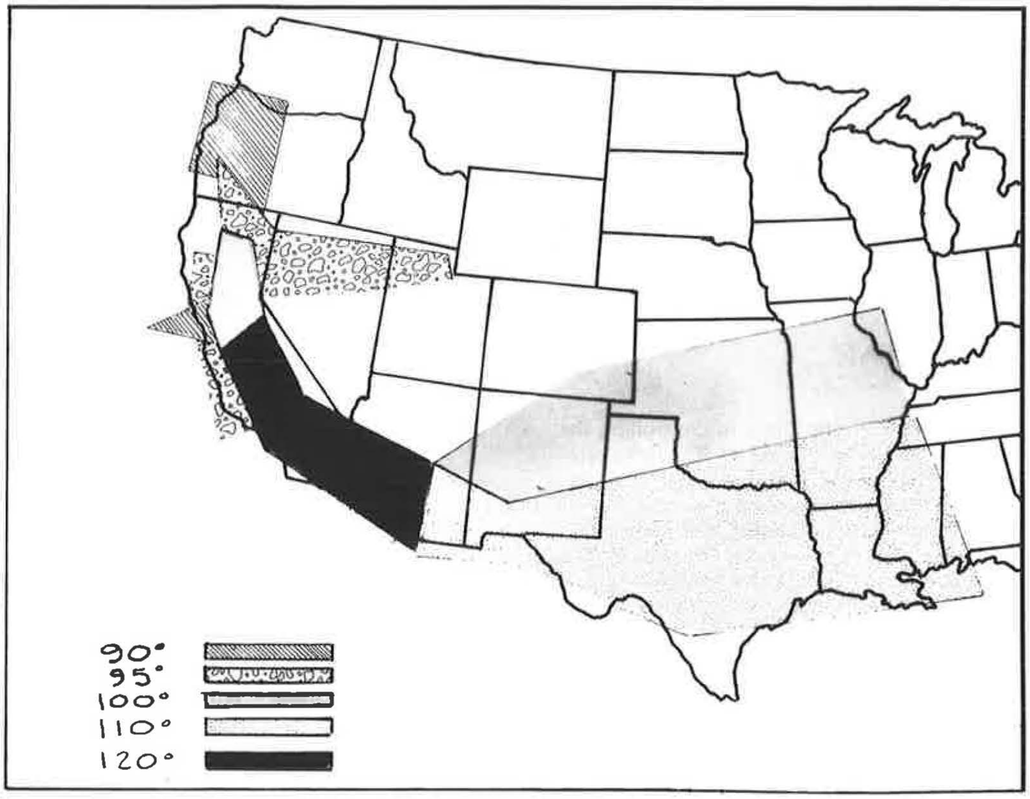

FIGURE 1 Southern Pacific Lines zone map of minimum neutral rail temperatures.

It has been learned from track buckling research and experience that track buckling can occur when rail temperature increases 60° or more above the adjusted rail temperature. In no instance on the Southern Pacific system does the highest rail temperature found in the zone exceed by more than 40°F the required minimum rail neutral temperature identified on the zone map. Instructions require that if the rail temperature difference between laying and current reading exceeds 40°F, the rail must be destressed.

Instructions to maintenance employees include procedures for the proper laying of CWR. Important guidelines in the instructions for controlling proper rail laying temperature include

- Laying rail at or above the minimum neutral rail temperature for the zone, which varies by zone between 90° and 120°F.
- Using a rail heater when laying more than 1,400 ft and the temperature is less than the minimum neutral rail temperature.
- Using a rail heater immediately before anchoring and spiking and in conjunction with a rail vibrator.

The instructions also include procedures for the proper maintenance of CWR. Important guidelines in the instructions for maintaining proper rail temperature include the following:

- When defective rails are replaced, the amount of rail should not be increased.
- Roadmasters are requried to keep a record of all locations that require cutting in a piece of rail, making a weld, or repairing a cold weather pull-apart.
- Identification is to be placed on the web of the rail by the welder that indicates the initials of the welder, the date the weld was made, the actual rail temperature, and the adjusted rail temperature.

A detailed procedure for destressing CWR also is included in the instructions.

Included in the chief engineer's instructions are common standard diagrams used by the track foreman. The important standards pertaining to track buckling prevention include the following:

- Ballast shoulder should be a minimum of 6 in. (Twelve in. is recommended on the high side of curves, areas of poor subgrade conditions, and areas in which track buckling has occurred.)
- The rail anchor pattern should consist of four anchors boxed on every other tie.

District engineers have the authority to add anchors where required, including the approaches to road crossings, bridge approaches, track crossings, and turnouts. In 1981 the rail anchor pattern was changed from four anchors boxed on every third tie to four anchors on every other tie. It was planned to change to the new standard during rail relays, but the change was begun with the tie renewal programs. Approximately 80 percent of the Southern Pacific Lines' welded rail is now anchored to the new standard.

DISTURBED TRACK

Weakened track conditions caused by low track resistance or alignment deviations must be controlled by maintaining sufficient lateral track resistance and maintaining track alignment to close tolerances. Lateral track resistance due to thermal loads becomes a factor when CWR is in compression. Instructions of the Southern Pacific Lines contain guidelines for protection of production and maintenance work on days when temperatures are above 90°F. These guidelines require graduated slow orders to be placed for a minimum of 72 hr on track where various types of maintenance work have been performed for a specified time period. For example, if a production tie gang replaces defective ties out-of-face in track territory with freight speeds of 65 mph (FRA Class 5), the first 24 hr requires a 20-mph slow order, the second 24 hr requires a 40-mph slow order, and the third 24 hr requires a 60-mph slow order.

It has been learned through track buckling research and experience that track resistance decreases as a result of disturbance of the ballast section by work such as track surfacing. It is only through train tonnage, the use of track compactors, or both that track will recover to its maximum lateral resistance. The placement of a slow order on continuously welded track that is in compression after ballast has been disturbed allows for the safe passage of trains while lateral resistance is being restored. Track work that disturbs the ballast section is performed, when practical, on CWR at or below the temperature at which the rail was laid or adjusted. This means that track work that disturbs the ballast is kept to a minimum during the months when track buckling is likely to occur (May through August). However, it is not possible to schedule major tie replacement work around this period. Therefore, steps are taken to destress track that is in compression within these limits, and a track compactor is sometimes used to increase lateral track resistance.

VEHICLE LOADS

Vehicle loads must be controlled by the locomotive engineer's use of good train handling techniques. It has been learned through track research and experiences that track buckling has been induced in areas of disturbed track by forces generated by train handling. Instructions to locomotive engineers require use of good train handling techniques in areas of disturbed track and are detailed in Operating Rule 465, as follows:

> OPERATING RULE 465
> Train Handling Over Disturbed Track
> When a train order is received containing the following wording, "BETWEEN (Milepost) AND (Milepost) BE GOVERNED BY RULE 465", engineer must handle the train so that track and structures within specified limits are subjected to a minimum of train handling generated forces.
>
> Adverse forces are imparted to track and structures as a result of excessive speed, harsh slack adjustments, moderate to high draft or buff forces and/or heavy train braking.
>
> These forces are substantially reduced when the engineer controls speed, allows power to drift, makes no slack adjustments and uses no automatic brake while train is passing through the restriction.
>
> As near as practical the engineer will use train handling techniques that reduce adverse forces by making power and brake adjustments prior to or following the restriction and by carefully controlling speed, use of automatic brakes and slack adjustments while train and engines are passing over the restriction.

Instructions to maintenance-of-way employees require issuance of a train order to comply with Operating Rule 465 to cover unstable track segments where buff and draft forces in train handling could induce track buckling. It is issued in addition to slow orders required by other instructions.

TRAINING

The main factor in the reduction of track buckling derailments on the Southern Pacific Lines has been ensuring that the rules and instructions for the prevention of track buckling are followed by employees performing the work. Track employees are trained by division managers, who use videotapes and other educational tools to discuss the reasons why track buckling occurs. Classes for key employees involved in prevention of track buckling are held by district engineers in early spring and early fall. These key employees include roadmasters, track inspectors, track foremen, bridge foremen, and welders. Work procedures to be followed during the summer months are discussed in detail at the spring meeting. Important topics covered include

- Inspection frequency during hot weather (minimum of three times per week in Class 4 and 5 track with 20 million gross tons or more annually; daily during peak temperatures);
- Warning signs to which inspectors should be alert, such as an unusual "wavy" appearance in tangent track, shifting of rail in plates or plate movements on ties, rail lifting in plates, and so forth.
- Required procedures to be followed when track work is done under temperatures of over 90°F;
- Proper application and use of Operating Rule 465; and
- When and how to destress CWR.

During the fall meeting, work procedures to be followed during the winter months are discussed in detail. Important topics covered include

- Proper procedure for repairing defective and broken rails and rail pull-aparts,
- Record-keeping requirements for repairing defective and broken rails and rail pull-aparts,
- Occurrence of track shifting caused by track surfacing work and its effect on lowering neutral temperature, and
- Record-keeping requirements for curves that have shifted.

It is stressed that all work must be done the right way the first time. However, it is recognized that conditions develop that require the addition of rail to the track to repair a pull-apart. These conditions could result from the unavailability of manpower when the pull-apart occurred, broken hydraulic rail expanders, or limited on-track time. Foremen are instructed that when this occurs, the amount of rail added as a result of the pull-apart must be recorded and reported to their

supervisors. The next available work period must be utilized to make the proper repair.

To assist district engineers in training their employees, with the permission of the CSX Transportation Company, videotapes *Prevention of Track Buckling* and *Track Maintenance Procedures for Destressing Continuous Welded Rail* are provided.

Locomotive engineers are trained by the road foreman of engines in the proper procedure for handling trains over disturbed track in compliance with Operating Rule 465. A videotape, *Operating Rule 465, Train Handling Over Disturbed Track*, is shown to every locomotive engineer each spring. Discussed in the tape are components of the track structure, the causes of high lateral train-generated forces, and train handling techniques that a locomotive engineer can use on various kinds of terrain to reduce the amount of lateral force placed on the track structure.

CONCLUSION

Track buckling is caused by high compressive forces caused by thermal loads and low neutral temperatures, weakened track conditions due to low track resistance or alignment deviations, and vehicle loads. Because of the inability of anyone to efficiently determine the stresses in CWR accurately, it is believed that the instructions in the form of guidelines for employees to use when performing track work on CWR, the biannual training programs, and the desire to motivate employees to do their work the right way the first time are the best weapons in helping employees prevent track buckling derailments. The best rules, practices, and instructions will never ensure that track buckling will not occur, but, as demonstrated in the successful reduction of buckling derailments, the Southern Pacific Lines and other carriers are winning in the solution of this problem.