Maintenance Procedures for Lateral Track Stability

P. R. OGDEN

The maintenance-of-way procedures and training programs of the Norfolk Southern Corporation for maintaining track stability and preventing buckled track when working with welded rail are described in this paper. The possibility of track buckling is a constant threat. Track alignment problems can be reduced substantially if maintenance personnel stay alert and follow established instructions for maintenance-of-way activities, such as rail laying, tie renewal, surfacing, and smoothing operations. Two steps were taken to improve the effectiveness of prevention of track buckling on the Norfolk Southern rail system. First, instructions for track maintenance activities relative to stability were consolidated into one maintenance-of-way procedure, Standard Procedure 390, Maintaining Track Stability. Second, training programs were established for all first-line supervisors and track foremen to improve their knowledge of why track buckles and how to prevent it.

Lateral stability of continuous welded rail (CWR) concerns everyone involved in track maintenance. It is a timely subject, especially when seasonal change causes the average air temperature to rise each day, and a corresponding rise in rail temperature occurs.

It has been stated and written that the two most outstanding advancements in track maintenance in the last 50 years are the mechanization of maintenance-of-way work and the development of CWR. On the Norfolk Southern rail system, both play a significant role in efforts to control cost and stay competitive in today's transportation market. However, to maximize all the advantages of CWR, track buckling must be avoided. To achieve stability, close attention must be paid to a number of details, which is the topic of this paper.

Two factors that have helped improve the lateral track stability of Norfolk Southern rail stand out. First was the establishment of a written procedure for maintaining track stability with checks and balances to ensure that it is understood and followed—MW&S Standard Procedure 390, Maintaining Track Stability. The second factor is an ongoing program to train field personnel to better understand the problems and solutions associated with buckled track.

BACKGROUND

The use of CWR has been a big part of the maintenance program at Norfolk Southern for a number of years. The first welded rail was laid on Norfolk Southern in 1958. The current 5-year plan is to lay about 600 mi of CWR each year. The Norfolk Southern rail system has over 25,500 track mi, of which 14,910 mi is welded—13,072 mi on the main line and 1,838 mi in yards and sidings.

As the mileage of CWR in track rose in the late 1960s and early 1970s, sun kinks, buckled track, and derailments caused by buckled track occurred.

Track buckles for many reasons. To help understand these reasons more clearly, research has been conducted in the last two decades by the railroad industry, FRA, and others. Greater knowledge on working with welded rail has been gained over the past 15 to 20 years from research and from cooperation among railroads. However, there is no substitute for the experience gained from working through one's own problems and finding one's own solutions.

In the early 1970s, one of the experiences was a derailment that involved a passenger train. A small maintenance gang had spotted ties on a welded rail at a 4-degree curve. It was a hot spring day, shortly after noon. The gang stopped work to allow the train to pass. Contrary to existing instructions concerning tie replacement in warm or hot weather, a slow order was not placed. Consequently, the track where the new untamped ties were located moved under the train, which was running at timetable speed, resulting in a derailment. Several problems relative to the existing instructions and the first-line supervisor's compliance with and understanding of those instructions were discovered in the postderailment investigation.

IMPROVED MAINTENANCE PROCEDURES

To correct these problems and improve overall performance, it was decided that two things had to be done. First, a set of instructions and standards had to be written for working with welded rail that would be clear, concise, and easily understood by all maintenance-of-way employees, including the track foreman. All new and existing instructions related to track stability were consolidated into Standard Procedure 390. The purpose of the procedure is to establish a uniform system for prevention of buckled track. Second, training programs were established to help employees better understand the characteristics of CWR and the caution that must be taken when laying and working with welded rail.

The instructions and the training programs have contributed more than anything else to the prevention of track buckling on the Norfolk Southern railroad.

Standard Procedure 390

The subjects covered in Standard Procedure 390 are as follows:

Norfolk Southern Corporation, 99 Spring Street, S.W., Atlanta, Ga. 30303.

- Track stability factors,
- Track conditions,
- Track inspection,
- Crosstie or switch tie replacement,
- Surfacing track,
- Combined timbering and surfacing,
- Measurement of track behind surfacing work,
- Rail laying by system gangs,
- Smoothing,
- Cribbing track and spot undercutting,
- Undercutting track out of face,
- Bridge work,
- Laying or transposing welded rail by division maintenance forces, and
- Adjusting welded rail.

Standard Procedure 390 is shown in Figure 1. A discussion of the more important subjects follows. Some of these guidelines are standards within the industry, whereas some are unique to Norfolk Southern.

Track Stability Factors

The procedure starts with several general statements that constitute the theme throughout.

1. Track with CWR must not be disturbed without using the proper slow orders.
2. Track disturbed by new ties, surfacing, or smoothing can lose up to 80 percent of its original resistance to lateral forces.
3. Once disturbed, track stability can only be restored by tonnage at a reduced train speed or by the use of a ballast stabilizer.

Track Conditions

CWR represents a revolutionary advancement in track maintenance by controlling or minimizing the natural expansion of steel caused by temperature increases. This is achieved not by cancelling a physical law, but by preventing rail expansion by using a rigid track structure that is well anchored and embedded in ballast.

Many components make up a track structure, but two of the more important parts in terms of lateral track stability are ballast and rail anchors.

All ballast sections must be maintained to the following minimum standards:

Ballast Location	*Standard*
Jointed rail	
Tangent track	Slopes from ends of top of ties down to roadbed
Curve	
Low side	Same as tangent track
High side	Extends laterally 6 in. from ends of top of ties before sloping down to roadbed
Welded rail	
Tangent track	Extends laterally 6 in. from ends of top of ties before sloping down to roadbed
Curve	
Low side	Same as tangent track
High side	Extends laterally 12 in. from ends of top of ties before sloping down to roadbed

For work that disturbs the track, there are several reminders throughout the procedure that slow orders are not to be removed until a standard ballast section has been restored.

Rail Anchors

Compressive forces are created by the prevention of rail expansion. No part of the track is more important for controlling these forces than the rail anchor.

The point emphasized in Procedure 390 is that all anchors must be applied as required. All missing or defective anchors should be replaced in each timbering cycle. The rail anchors serve no purpose unless they are boxed against the crossties. Therefore, each timbering and surfacing gang is equipped with machines to tighten all anchors against the ties.

The standard pattern of Norfolk Southern is to box anchor every other tie. On curves of 3 degrees and more, every tie is box anchored. All ties are box anchored at ends of trestles and ribbons, and into and away from turnouts.

Track Inspections

Track inspection is the first line of defense for detecting any flaws in the track. During a sudden rise in or extremely high rail temperatures, CWR must be inspected frequently and sometimes daily. This requires some flexibility in work hours and weekend schedules to ensure that employees get time off, while at the same time the needed protection for the safety of train operations is provided.

Some rules and guidelines are as follows:

1. All scheduled track inspections must be maintained.
2. Additional inspections are to be made during sudden changes in temperatures where welded rail or recently disturbed track is subject to misalignment.
3. Weekend inspections are to be made during periods of extreme temperature changes. When a slow order is used for tight track, weekend inspections are necessary.
4. Special attention must be given to track on curves, in dips, at the ends of bridges, and on heavy grades; recently disturbed track; and track worked during the past winter.

Rail temperatures and work situations that disturb the track are key factors in determining when each rule applies. Maintenance personnel must be fully aware of the situations that disturb the track and cause a loss of resistance to lateral forces. Tie renewal, surfacing, and smoothing can create these temporary conditions. When this work is done with changing or high rail temperatures, extreme caution must be taken to prevent track buckling.

Tie Replacement, Surfacing, and Smoothing

Tie renewal, surfacing, and smoothing are each covered separately in the procedure, but because the instructions and guidelines are similar, the three functions are covered together here.

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SCOPE AND NATURE

To establish a uniform system for prevention of buckled track due to extreme changes in rail temperature.

OUTLINE OF PROCEDURE

The possibility of track buckling is a constant threat and only alertness, good common sense, and adherence to the following instructions will keep the track in line for the safe operation of the railroad.

PROCEDURE

1. TRACK STABILITY FACTORS ARE:

   .01 Track disturbed by surfacing or smoothing can have as little as 20% of the holding power (lateral restraint) of undisturbed track - That is a loss of 80%.

   .02 Track Stability, both lateral and vertical, is gained by tonnage over the track or by ballast compaction to a smaller degree.

   .03 Track with continuous welded rail must not be disturbed without the proper slow order.

   .04 Slow orders must be based on track stability. Stable track is obtained by letting the track settle, under tonnage, at a reduced speed.

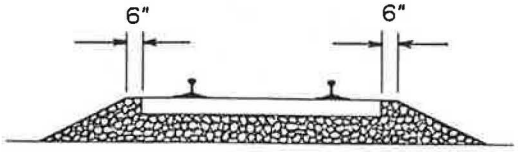
2. TRACK CONDITIONS.

   .01 Ballast Sections.

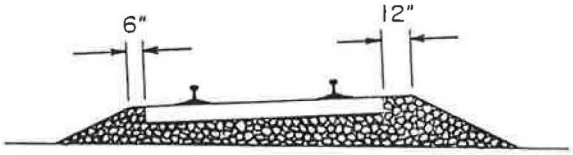
   a. A full standard ballast section must be maintained for jointed and welded rail track sections.

   b. Standard ballast sections are as shown in the sketches below and on the next page.

WELDED RAIL



TANGENT TRACK



CURVE TRACK

* Denotes revision to procedure last issued 11-01-86.

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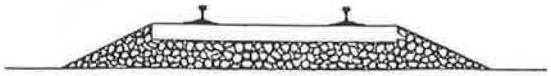
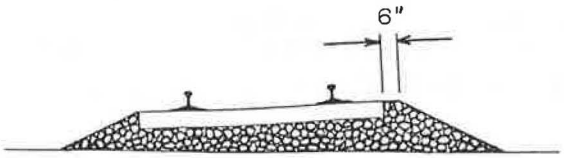
FIGURE 1 Standard Procedure 390, Maintaining Track Stability.

ALL PREVIOUS PROCEDURES AND INSTRUCTIONS IN CONFLICT HEREWITH ARE SUPERSEDED TO THE EXTENT OF THE CONFLICT UPON RECEIPT OF THIS PROCEDURE.

JOINTED RAIL



TANGENT TRACK



CURVE TRACK

.02 Crossties and Switch Ties.

Tie condition should be of sufficient strength to hold gage, surface, and alinement to prevent rail buckling.

.03 Rail Anchors.

a. Rail must be anchored in accordance with applicable procedure(s).
b. In addition to anchors required by above instruction, sufficient anchors must be added to any moving rail which is subject to getting out of line or where anchors do not have sufficient holding power.

.04 Tight Track.

a. Adjustment by cutting may be necessary to welded rail which is tight or not properly adjusted.
b. When track is known to be tight or has moved out of line at the end of a bridge where expansion joints do not exist, it is necessary that rail be cut and adjusted in order to relieve stresses in the track rather than by lining the track.
c. Lining of curves outward may be required for curves which have moved inward due to low temperature from cold weather.
d. Slow Orders must be placed at locations subject to getting out of line until the track condition has been corrected.

3. TRACK INSPECTIONS.

.01 All scheduled track inspections must be maintained.

.02 Additional inspections will be made during sudden changes in temperature where welded rail or recently worked loose track will be subject to getting out of line.

.03 During periods of excessive temperature changes, weekend inspections will be made when required. When a slow order is being run because of tight track, it is necessary to make inspections on Saturday and Sunday.

.04 Special attention must be given to track on curves, in dips, at the ends of bridges, heavy grades, recently disturbed track or track worked during the past winter.

FIGURE 1 *continued*

ALL PREVIOUS PROCEDURES AND INSTRUCTIONS IN CONFLICT HEREWITH ARE SUPERSEDED TO THE EXTENT OF THE CONFLICT UPON RECEIPT OF THIS PROCEDURE.

4. CROSSTIE OR SWITCH TIE REPLACEMENT.

.01 Whenever crossties or switch ties are replaced, a slow order must be used in accordance with instructions below. The foreman or person in charge of the work is responsible for placing the slow order.

a. A 10 m.p.h. slow order must be used in welded and jointed rail territory when the rail temperature is 110°F or above.
b. A slow order of 25 m.p.h., maximum speed may be used when the rail temperature is less than 110°F. Slow orders between 10 and 25 m.p.h. cannot be used on jointed rail.
c. If in doubt as to temperature, follow 110°F or above rail temperature instruction.
d. When a slow order of less than 25 m.p.h. is used, the passage of two tonnage trains is required before slow order is raised.
e. A slow order of 25 m.p.h. maximum speed must be in effect for a sufficient time beyond the work period so that the track will become settled and not be run over by trains at timetable speed immediately after having been disturbed.
f. When the 110°F rail temperature instructions are used, slow orders must remain in effect for at least 2 days of traffic.

.02 Newly installed ties are to be spiked and rail anchors applied in the prescribed spiking and rail anchor pattern at time of installation.

.03 All newly installed ties in welded rail main track must be power tamped before slow order is removed if installed ties exceed two per 39 foot rail.

.04 Upon completion of tie replacement, ballast section must be restored to standard before slow order may be removed.

.05 Removal of Slow Orders.

a. System Gang Work. The System Gang supervisor is responsible for ensuring removal of slow orders unless gang has moved 10 miles or more to a new work location, in which case the track supervisor/roadmaster is responsible for removing the slow order after personal inspection. They must confer with one another to be sure that this is handled properly.
b. Line Maintenance Work. The track supervisor/roadmaster, is responsible for ensuring the removal of the slow order.

5. SURFACING TRACK.

.01 Whenever surfacing work is performed, a slow order must be used in accordance with instructions below. The foreman or person in charge of the work is responsible for placing the slow order.

a. A 10 m.p.h. slow order must be used in welded and jointed rail territory when the rail temperature is 110°F or above.
b. A slow order of 25 m.p.h., maximum speed may be used when the rail temperature is less than 110°F. Slow orders between 10 and 25 m.p.h. cannot be used on jointed rail.
c. If in doubt as to temperature, follow 110°F or above rail temperature instruction.
d. When a slow order of less than 25 m.p.h. is used, the passage of two tonnage trains is required before slow order is raised.
e. A slow order of 25 m.p.h. maximum speed must be in effect for a sufficient time beyond the work period so that the track will become settled and not be run over by trains at timetable speed immediately after having been disturbed.

.02 The runoff made at end of the day must be left in good cross level and alinement with a full standard ballast section, and no condition left which could contribute to buckled track.

FIGURE 1 *continued*

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.03 If insufficient ballast section exists behind newly surfaced track, the gang supervisor is responsible for placing a proper slow order and advising the track supervisor/roadmaster or division engineer of the condition. The track supervisor/roadmaster or division engineer is responsible for having the ballast section restored and removal of slow order.

.04 Removal of Slow Orders.

a. System Gang Work. The System Gang supervisor is responsible for ensuring removal of slow orders unless gang has moved 10 miles or more to a new work location, in which case the track supervisor/roadmaster is responsible for removing the slow order after personal inspection. They must confer with one another to be sure that this is handled properly.

b. Line Maintenance Work. The track supervisor/roadmaster, is responsible for ensuring the removal of the slow order.

6. COMBINED TIMBERING & SURFACING WORK.

01. Where tie installation is combined with surfacing, i.e., T&S, sections 4 and 5 of these instructions must be applied together. Where instructions combined may conflict, the most restrictive instructions apply and must be followed.

02. In addition, at end of the work week all disturbed track must be fully tamped.

7. MEASUREMENT OF TRACK CONDITIONS BEHIND SURFACING WORK.

.01 Rail Temperature Measurements (System Gangs).

a. Rail temperatures will be taken three times each day and reported to the maintenance of way equipment and material coordinator in Atlanta (Microwave Northern Region 529-2401 or Southern Region 529-1466) along with the daily production report.

b. The temperature will be measured at start of work, middle of day, and at end of work.

c. Rail temperature is measured on the shady side of the web of rail. The thermometer must remain on the rail for at least five minutes and be away from any form of artificial cold or heat other than when rail heater has been used in prescribed manner.

.02 Track Movement Measurements.

a. Where track will be surfaced at a rail temperature of 50°F or below, a Line Maintenance officer will set reference stakes at 3 or more locations on each curve before track is surfaced by T&S or Surfacing Gang.

b. Reference stakes will be set along curves clear of gang activities.

c. A Line Maintenance officer will record the amount of movement one week after each curve is surfaced and furnish the measurements on the prescribed form (see exhibit i) to the office of chief engineer Line Maintenance.

d. The office of chief engineer Line Maintenance will consolidate the reports and furnish summary report to chief engineers Line Maintenance with copies to engineers maintenance of way and division engineers of curve locations where curves moved one inch or more inward at any single point.

e. The division engineer will be held responsible for having curves with average inward movement of one inch or more lined out prior to hot weather, or else track will be slow ordered in hot weather until lining is complete.

8. RAIL LAYING BY SYSTEM GANGS.

.01 When system rail laying schedules are prepared, the chief engineer program maintenance provides a copy of the schedule to the senior chief engineer bridges and structures in order that the Bridge Department can determine required anchoring or use of expansion joints at bridges.

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FIGURE 1 *continued*

ALL PREVIOUS PROCEDURES AND INSTRUCTIONS IN CONFLICT HEREWITH ARE SUPERSEDED TO THE EXTENT OF THE CONFLICT UPON RECEIPT OF THIS PROCEDURE.

.02 Whenever rail is laid in tracks with a timetable speed greater than 25 m.p.h., a slow order must be used. The system gang supervisor is responsible for ensuring the placement of the slow order.

a. Recommended maximum speeds for slow orders when laying rail is 25 m.p.h.
b. Dependent upon other track conditions (such as alinement, tie condition, surface, or rail condition) a speed less than 25 m.p.h. may be required.

.03 Before slow orders can be raised:

a. All joints tightly bolted with at least two bolts each rail end,
b. rail spiked in the prescribed pattern,
c. rail anchors must be installed tight against the ties in prescribed pattern,
d. all down ties fully tamped, and
e. standard shoulder ballast section must be provided.

.04 Where speed has been restricted to less than 25 m.p.h. for rail laying, the passage of one tonnage trains is required before raising the speed to 25 m.p.h. or greater

.05 The division engineer or the track supervisor/roadmaster after personal inspection of the rail laid will determine the appropriate speed to run on the track.

.06 If the rail temperature is below 80°F, rail heater must be used to raise the rail temperature ahead of spiking to a temperature of 85°F to 100°F, ideally 95°F.

.07 Throughout welded rail laying, slack must be removed by use of rail pulling equipment.

.08 The rail gang supervisor is responsible for ensuring that the rail temperature be taken at time of anchoring for each strand (single gang) or each ribbon (dual gang) and reporting to the maintenance of way equipment and material coordinator in Atlanta (microwave Northern Region 529-2401 or Southern Region 529-1466) along with the daily production report. These temperatures will in turn be furnished to the office of chief engineer Line Maintenance.

.09 The office of chief engineer Line Maintenance will prepare/update rail temperature charts and furnish to the chief engineers Line Maintenance, engineers maintenance of way, and the division engineers for their territory.

.10 The division engineers must review the rail temperature of all welded rail laid on his territory and make adjustments where required.

9. SMOOTHING.

.01 Good judgement should be exercised in smoothing during hot weather and extreme temperature changes.

.02 Welded rail should not be smoothed when rail temperature is above 110°F unless such smoothing is necessary to afford safe passage of trains.

.03 Slow Orders.

a. A 10 m.p.h. slow order must be placed at any location in jointed or welded rail territory when it is necessary to smooth track and the rail temperature is 110°F or above.
b. A slow order of 25 m.p.h. maximum speed may be used when track is smoothed at a rail temperature of less than 110°F. Slow orders between 10 and 25 m.p.h. cannot be placed on jointed rail.
c. If there is a possibility that rail temperature will rise to 110°F later in the day, a 10 m.p.h. slow order must be used until track has settled under traffic and is safe for timetable speed.
d. A slow order of 25 m.p.h. maximum speed must be in effect for a sufficient time beyond the work period so that the track will become settled and not be run over by trains at timetable speed immediately after having been disturbed.
e. The track supervisor/roadmaster, assistant track supervisor/assistant roadmaster, or the foreman in charge of the work is responsible for placing and removing the slow order.
f. If more than 4 continuous ties are hand tamped in welded rail territory, a 25 m.p.h. slow order must be in effect until track is power tamped and track is settled for timetable speed.

FIGURE 1 *continued*

ALL PREVIOUS PROCEDURES AND INSTRUCTIONS IN CONFLICT HEREWITH ARE SUPERSEDED TO THE EXTENT OF THE CONFLICT UPON RECEIPT OF THIS PROCEDURE.

.04 When smoothing or restoring prescribed elevation in curves, each tie must be fully tamped under each rail to eliminate voids between tie and ballast section.

.05 Tie cribs must be filled with ballast at any point disturbed by smoothing and track left in good alinement.

.06 When Line Maintenance smoothing gangs are performing any surfacing work, they will also be governed by the instructions under "Surfacing Track" in 5.01 d on page 3.

10. CRIBBING TRACK AND SPOT UNDERCUTTING.

.01 A 25 m.p.h. maximum speed slow order must be used when cribbing tracks of foul ballast, cribbing road crossings, and spot undercutting.

.02 After a full standard ballast section has been restored, a slow order of 25 m.p.h. maximum speed must be in effect for a sufficient time beyond the work period so that the track will become settled and not be run over by trains at timetable speed immediately after having been disturbed.

11. UNDERCUTTING TRACK OUT OF FACE.

.01 The track supervisor/roadmaster, division engineer or an officer designated by the division engineer must be with any track undercutting operation and is responsible for ensuring placement and removal of slow order.

a. Following the undercutting operation, a slow order of 10 m.p.h. must be used and must remain for a minimum of 24 hours.
b. After 24 hours, speed may be increased to a maximum of 25 m.p.h. (Jointed rail may not have a slow order between 10 and 25 m.p.h.) The 25 m.p.h. slow order must remain in effect as follows:

Annual Tonnage	Time, at least
Less than 10 million	4 days of traffic
10 million or greater	2 days of traffic

c. Tangent track that cannot be restored to proper alinement during the heat of the day (noon to 6 p.m.) account tight track must be cut and adjusted in accordance with applicable procedure before slow order is raised or removed.

.02 Measurements of track movement on curves behind surfacing work done in conjunction with undercutting operation will be as covered in section 7 with the following exceptions:

a. Measurements will be made on curves if rail temperature is 70°F or less when track is undercut.
b. Stakes will be set clear of all work activities and initial measurements made before track is undercut.

*12. BRIDGE WORK.

* .01 A slow order will be used when bridges ties are installed.

* .02 Renewing Bridge Ties On Open Deck Bridges in Welded Rail.

a. When the rail temperature is in the range of 10°F below the laying or adjusted temperature up to 110°F, not more than ten consecutive ties may be unspiked at one time, and then only when adjacent ties are secured in place with drift or hook bolts, AND rails are strutted apart with substantial timber and bound together tightly with load binder or come-along.
b. When welded rail temperature is above 110°F and the rails are bound as required in sub-paragraph a above, not more than five consecutive ties may be unspiked at one time.

* .03 When jointed rail is extremely tight due to hot weather conditions, it should be handled as welded rail.

* .04 When renewing ties on ballast deck bridges, the instructions in section 4 (Crosstie or Switch Tie Replacement) governs.

* .05 When a B&B gang raises or disturbs the track approach to an open deck bridge, all items under section 9 (Smoothing) must be observed by the B&B forces.

* Denotes revision to procedure last issued 11-01-86.

FIGURE 1 *continued*

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.06 When track is known to be tight or has moved out of line at the end of a bridge where expansion joints do not exist, it is necessary that the rail be cut and adjusted in accordance with applicable procedure in order to relieve stresses in the track rather than by lining.

.07 When ties are renewed or track is otherwise disturbed across a bridge or within 200 feet of a bridge, special attention is required to ensure that rail anchors are installed in accordance with standards and expansion joints, where used, are in proper condition before temporary speed restrictions are removed.

13. LAYING OR TRANSPOSING WELDED RAIL BY LINE MAINTENANCE.

.01 Whenever rail is to be laid across bridges, the division engineer is to notify the B&B supervisor well in advance of laying so that the Bridge Department can determine required anchoring or use of expansion joints.

.02 The existing applicable procedures are to be followed when rail is laid or transposed by Line Maintenance forces. It is imperative that the reporting be made in accordance with exhibit ii.

.03 The track supervisor/roadmaster or an officer designated by the division engineer must be with any Line Maintenance forces transposing or laying welded rail.

.04 Transposing or replacement of curve worn rail shall be performed between May 15th and September 15th where possible.

.05 When welded rail is laid, rail must be anchored at a rail temperature of 75°F or greater.

.06 When a rail heater is used the rail will be heated to a rail temperature between 85°F and 100°F, ideally 95°F, ahead of the spiking operation.

.07 The division engineer must review the rail temperature of all welded rail laid on his territory and make adjustments where required.

14. ADJUSTING WELDED RAIL.

.01 The existing applicable procedures are to be followed when welded rail is adjusted. It is imperative that the required reporting be made in accordance with exhibit iii.

.02 Rail Adjustment by Tie, Surfacing, or T&S Gangs.

a. Track being worked by T&S, Tie, or Surfacing Gangs may require that the rail be adjusted immediately to maintain proper alignment of track.
b. Since the rail is in compression, it must be cut with a torch, realigned, holes drilled, and angle bars applied.
c. Each T&S, Tie, and Surfacing Gang is required to have available:

(1) A rail drill with proper size bits.
(2) Two pair of angle bars of same weight as rail being worked, with necessary bolts and nutlocks.

d. When System Gangs have made emergency rail adjustments, they must notify Line Maintenance immediately so that Line Maintenance forces can complete adjustment of rail in accordance with applicable procedures.

.03 Rail Adjustment by Line Maintenance. The track supervisor/roadmaster or individual designated by the division engineer must be with any Line Maintenance forces adjusting welded rail.

APPROVED:

H. Rose

Assistant Vice President-Maintenance

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FIGURE 1 *continued*

When crossties or switch ties are replaced or surfacing and smoothing is performed, a slow order must be used as follows:

1. A 10-mph slow order must be used in welded- and jointed-rail territory when the rail temperature is 110°F or above.
2. A slow order not to exceed 25 mph should be used when the rail temperature is less than 110°F.
3. If the exact temperature is not known, the instructions for rail 110°F or above should be followed.
4. When a slow order of less than 25 mph is used, the passage of two tonnage trains is required before the order can be lifted.
5. A slow order of 25 mph must be in effect for a sufficient length of time after work is performed so that the disturbed track becomes settled before trains are run over it at timetable speed.
6. When the 110°F rail temperature instructions are used, slow orders must remain in effect for at least 2 days of traffic.
7. For smoothing, if more than four continuous ties are hand tamped in welded-rail territory, a 25-mph slow order must be in effect until the track is power tamped and has settled.
8. Upon completion of work, the ballast section must be restored to standard condition before the slow order may be removed.

Because rail temperature is critical to lateral stability, it is the motivating factor for the formulation of many of Norfolk Southern's guidelines. All production gangs are required to measure rail temperatures at least three times daily. These temperatures are reported along with the production reports to the Atlanta office.

In the early 1970s several buckled-track derailments occurred on curves that had been surfaced the previous winter. Because the track had been worked below the rail-laying temperature, the disturbed track moved inward during the work cycle. No record was made of this movement, and therefore no adjustment was made to the rail. As a result, each spring and summer track alignment problems occurred. To prevent these problems, instructions were written to measure movement of curves that are disturbed during cold weather.

Measurement of Track Conditions Behind Surfacing Work

When track is to be surfaced at a rail temperature of 50°F or below, reference stakes are to be set on curves and measured ahead of the work.

One week after the production gang performs its work, measurements are to be taken to record any movement of the curve. This information is furnished to the chief engineer's office where a report is prepared listing all locations that moved inward 1 in. or more. This information is sent to the division engineer, who is responsible for adjusting rail on all curves that moved 1 in. or more inward, on average.

It is not always possible to work track at or above the rail-laying temperature, but the practice of measuring curves for inward movement has prevented many problems.

Rail Laying

There is no substitute for a good rail-laying job to prevent lateral track stability problems. A number of quality control measures must be performed correctly to achieve stability, such as line, gage, application of all fasteners, plates, spikes, and others. Each is covered in the procedure; only a few of the instructions relative to the establishment of the rail-laying temperatures are mentioned here.

1. If rail temperatures are below 80°F, a rail heater must be used. Rail must be heated so that the temperature at the time of spiking and anchoring is 85° to 100°F, ideally 95°F.
2. Throughout welded rail laying, slack created by the rail heater and the laying process must be continuously removed by use of rail-pulling equipment.
3. The rail gang supervisor is responsible for taking the rail temperature for each ribbon just before the anchoring process.
4. Temperature charts of all rail-laying jobs are furnished to the division engineers, who must review the charts and make rail adjustments where required.

Other subjects, such as cribbing, undercutting, bridge work, transposing of rail, and adjustment of rail are covered in the procedure. These are all critical components of rail laying and are covered in some detail in Figure 1.

Train Handling over Welded Rail

Some people in the industry and some researchers contend that procedures should also be issued for train handling over welded rail to improve track stability. Although train operations can create conditions that may cause track alignment problems, Norfolk Southern has not issued guidelines for train operation. Problems usually occur at ends of bridges, on heavy grades, in dips, and on curves. For this reason special attention must be given to these locations during track inspections for any telltale signs of problems.

Although train handling itself is not covered in Norfolk Southern procedures, adequate protection against poor train handling over disturbed track is provided by slow-order procedures and track inspection requirements for critical locations.

This procedure, written with field personnel in mind, has been a significant factor in the prevention of buckled track on the Norfolk Southern rail system. Personnel have been given clear, precise guidelines to follow to avoid problems in situations that most likely will lead to unstable track conditions. This procedure was distributed to all field personnel in a pocket-size 3- by 5-in booklet. This was done so that the procedure would be in their possession at all times, in the field where needed, not in a standard procedure three-ring notebook back at the office.

Procedures and standards are an absolute necessity for a safe, uniform system of laying and maintaining CWR. However, the standards are effective only if they are properly communicated to and understood by all field personnel who actually perform the work.

Training Programs

Two steps are performed to communicate the procedures to the field personnel:

First, in the spring of each year, staff meetings are scheduled at several central points throughout the system. These meetings are conducted by the assistant vice president of maintenance and the chief engineers. The theme of the meetings is the prevention of buckled track. The discussions are primarily for the first-level supervisory officers, the field personnel. The reasons why sun kinks and buckled track occur are explained, and Standard Procedure 390 is reviewed section by section. These meetings are mandatory for all maintenance-of-way officers and have been part of the training program since 1974.

The second step is for the division engineers to take the message back to the field and review the instructions with the foremen.

This procedure is conducted annually. Some may ask, "Is it all really necessary?" Working with CWR must be given top priority for safety of operations, and this is one method of driving the point home to those actually involved in the day-to-day field work. After the inception of this program in 1974, the number of buckled-track incidents dropped dramatically.

These instructions are constantly reviewed and evaluated for effectiveness. After a recent review, the following training programs for field personnel were added.

1. All scheduled employees promoted to field track or bridge supervisory positions are given 2 weeks of classroom training with on-track instructions.
2. All officers and some scheduled track employees take a written exam on FRA track safety standards as part of the annual spring meetings.
3. Foremen and assistant foremen attend a formal training school consisting of 2 weeks of classroom work with on-track instruction.

These programs cover all phases of track maintenance, including Standard Procedure 390, and should improve the effectiveness of maintenance practices.

CONCLUSION

Have the procedures, guidelines, and training programs been effective? Employees of Norfolk Southern think so. Over the last 10 years the railroad has had 13 derailments caused by

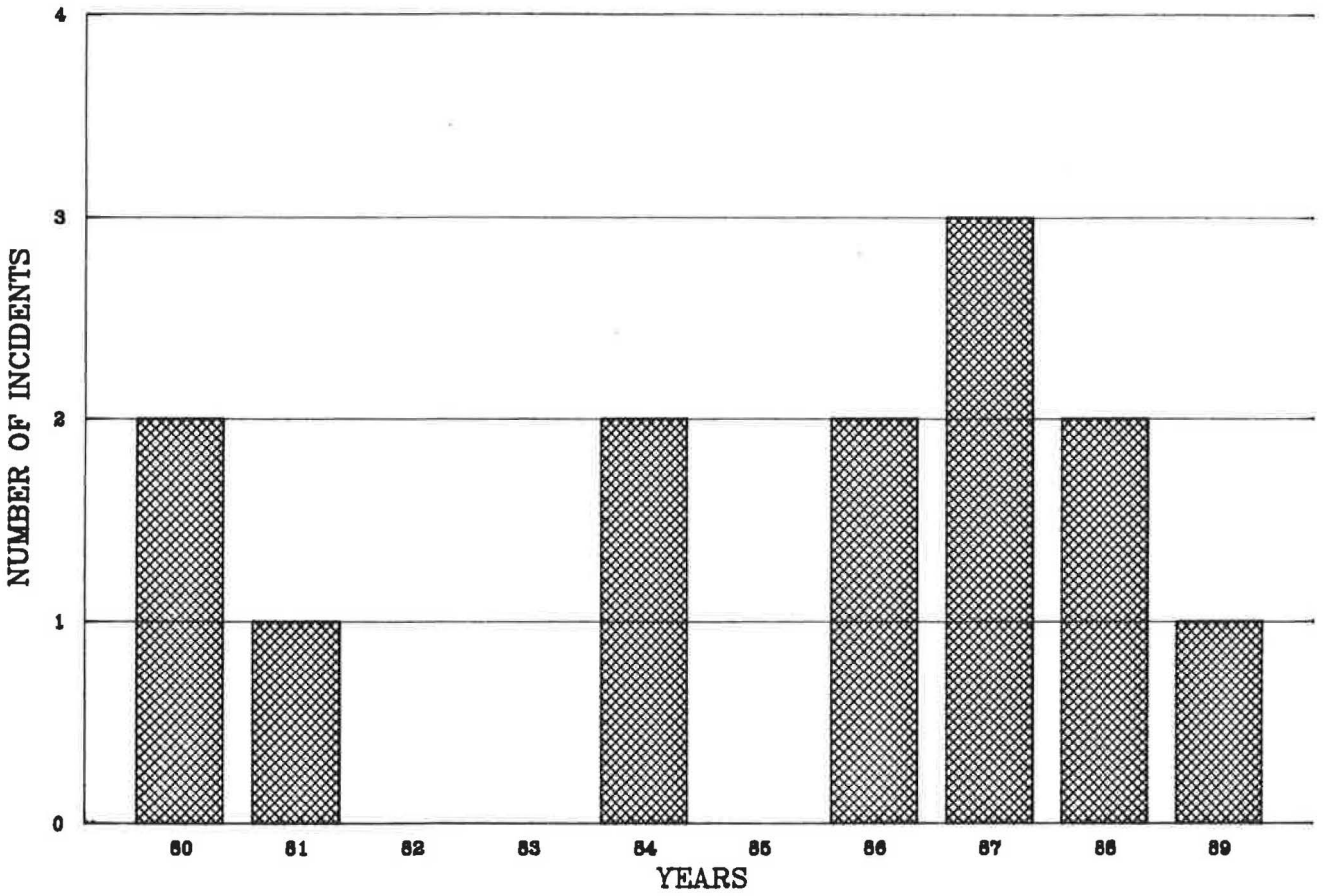

FIGURE 2 Norfolk Southern Corporation buckled-track derailments.

buckled track. No derailments occurred in 1982, 1983, and 1985 (Figure 2). Several of the derailments involved only one car.

In conclusion, it is believed that Norfolk Southern has a good program of instructions and guidelines for working with CWR. These instructions are based on sound engineering decisions for the conditions encountered on the rail system. To make this program effective, employee training is provided annually at the field level. Employees are committed to safety of operations, and it is believed that welded rail can be worked with safety under any circumstances if personnel are constantly alert to the conditions that can cause buckled track and follow the procedures for maintaining track stability.

A statement distributed at the annual spring meetings sums up Norfolk Southern's philosophy: Disturbed track in hot weather plus failure to follow instructions equals buckled track.