

Union Pacific's Approach To Preserving Lateral Track Stability

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The discussion is focused entirely on the in-track behavior of continuous welded rail (CWR) as it affects the lateral stability of railroad track. Lateral track stability is conditioned by the inter-related actions of the various elements of the vehicle and track system [various rail conditions, railhead profile, crosstie conditions, fastener type, ballast conditions, wheel profile, train braking, track alignment, track surface, lateral and vertical wheel load (static plus dynamic), etc.]. The critical element is rail in long, jointless lengths. The entire system must sustain longitudinal forces in the rail as temperature fluctuates. For years, track maintenance engineers have struggled to control CWR, that is, to lay CWR without building in future problems and to maintain CWR to avoid problems. Most engineers do not believe that this contest has been won; however, knowledge has increased in this area. The intent of this paper is to share Union Pacific's experience and provide help to others who are confronted with similar problems. Most instructions issued by Union Pacific to engineering forces, dispatchers, and train crews are included in this paper.

Union Pacific Railroad is the second largest railroad in the United States, with nearly 23,000 route mi linking western and Gulf Coast ports with the Midwest. Major categories of freight hauled by the railroad are coal, grain, chemicals, automotive parts and machinery, forest products, and intermodal traffic. In 1988 coal was the largest commodity in terms of total revenue ton-miles (28.2 percent), whereas chemicals traffic produced the highest percentage of freight revenue (21.7 percent).

BACKGROUND

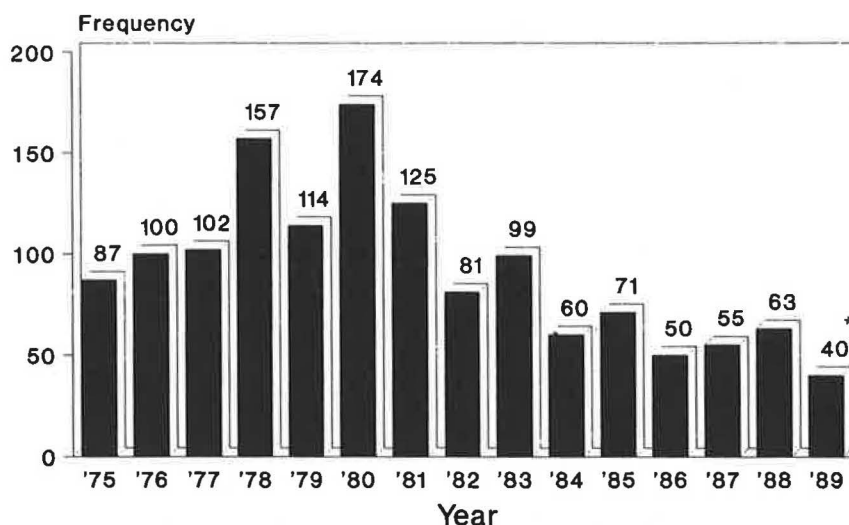
The Union Pacific Railroad as it exists today is a combination of the former Union Pacific (UP) and Missouri Pacific (MP), Western Pacific, and the Missouri, Kansas-Texas Railway. The MP began installing continuous welded rail (CWR) on main line tracks in 1955. UP did not begin using CWR on its main tracks until 1969, with complete utilization on curves in 1982. This was partially dependent on the ability to reliably weld premium rail of various metallurgies used in curves. In retrospect, the unknown contributed to the slow integration of CWR into UP railroad operations. Most track engineers now agree that, for a variety of reasons, CWR has helped more than any other development to reduce the total cost and improve the reliability of the track structure. A long-term goal of Union Pacific is to eliminate every joint in main line trackage, particularly around special track work.

In the 1960s the process of learning to live with CWR at Union Pacific commenced in earnest, with each year bringing more practical experience. With growing experience on Union Pacific, the rate at which CWR was installed in track increased. This trend was a mixed blessing. Figure 1, information provided by FRA, demonstrates that the number of derailments caused by buckled track for all U.S. railroads increased, year by year, right along with CWR installation, at least through 1980. Derailments declined through 1986, followed by a bottoming out. It appears that during early periods, when there was an increase in the installation of CWR, there was no effective lateral stability of the CWR track system.

This trend was evident on the Union Pacific. Ten years ago, a Union Pacific construction gang under the direction of a young supervisor was installing switch ties on the main line in Nebraska at the location of a future crossover. In the late afternoon, a van train traveling 70 mph hit the weakened track structure and derailed. The supervisor failed to properly distress the rail before beginning construction and had a slow order protecting the track only during assigned working hours. Years later, at another location, a section foreman replaced three defective ties under a joint in the morning. He then surfaced the track by hand, but failed to place the appropriate slow orders. Late that afternoon, the track buckled under an eastbound train. In addition to the improper slow orders, the track did not have a full ballast crib or proper shoulder ballast. In 1988, at a third location, a loaded eastbound coal train was traveling 50 mph on a hot afternoon. The train was entering a curve with tight rail. The engineer in control of the train applied the brakes to reduce speed. The track alignment was such that the curve was followed by a short stretch of tangent track followed by a large rigid structure, a bridge. The track buckled between the locomotives and the bridge. The suspect track should have been patrolled earlier in the day because of the hot weather.

Fortunately, no one was seriously injured in these derailments, but they did cause considerable freight, track, and equipment damage, and numerous train delays. In each of these examples, several events or interactions, some understood and some not, contributed to the derailments.

Beginning in the early 1970s, industry, through the Association of American Railroads, and FRA initiated a joint research effort designed to answer many of the questions about how the elements of the track system responded to realistic loads. This program, which is still in existence, devotes resources in time, effort, and capital to study CWR. It was from this base that the technical understanding of the behavior of CWR emerged to complement the accumulated



* Estimated Figure

FIGURE 1 Frequency of derailments caused by buckled track, as reported to FRA.

body of practical experience. Analysis and repeated field tests produced data that allowed track maintenance engineers to deal confidently with such concepts as

- The effect of track disturbance on reducing the lateral stability of CWR track and what is required in terms of traffic (load, vibration, and time) to effectively reconsolidate the disturbed ballast while restoring sufficient lateral stability to permit safe operation at regular speeds.

- Track-train dynamics, particularly the notion of progressive bending wave-rail action under vertical wheel loads that provides a partial explanation for lateral track shift under a moving train.

- The idea that the change with traffic and time of rail neutral temperature (zero longitudinal rail stress) is usually toward a lower number. It has been shown in repeated experiments that there is a definite range in which the temperature of rail steel must rise before lateral instability develops. To the extent that the stress-free rail temperature drifts downward, this range is narrowed, increasing the vulnerability of CWR track to lateral buckling.

Implicit in each concept is a reemphasis of the traditional qualities of a good track structure, including adequate amounts of dense ballast, secure rail fastenings, crossties capable of proper distribution of applied loads, and train operating procedures (usually braking) that minimize longitudinal load input at the wheel-rail interface, which are all predicated on the proper installation of the rail. With the change from bolted to CWR track, different quality deficiencies become critical, and the level of risk associated with a potential derailment changes accordingly.

For several years Union Pacific track engineers have been exposed to a "code of conduct" that must be followed if a railroad is to use CWR. The balance of this paper will describe how Union Pacific Railroad translated its own body of experience, tempered with selective reliance on investigative results, into the guidelines that enable the railroad to contend successfully with CWR.

The various railroads that now make up the Union Pacific began track buckling prevention programs in the 1960s with the development of various written instructions regarding rail laying temperatures and handling of track disturbed by maintenance. Eventually, the instructions were developed into formal chief engineer's instructions. The amount of CWR installed in track continued to increase, as did derailments due to buckled track. The following factors contributed to Union Pacific's decision to develop a formal track buckling prevention program:

- Some foremen and supervisors were not comfortable with the use of CWR and did not understand how to manage or work with it.

- Work by the Transportation Systems Center funded by the U.S. Department of Transportation greatly enhanced knowledge about CWR.

- CSX Transportation, then the Chessie Railroad, had developed an effective track buckling prevention training program that included a video and resulted in significant reductions in buckled track on their railroad.

- Union Pacific's top engineering department managers reviewed and understood the benefits of the Chessie program and decided to develop a Union Pacific program.

After the creation of the training program and instructions, plans were made to formally train all track department employees and other engineering employees within the company who could have an impact on buckled track or its prevention. This training is repeated annually, usually in the late winter. The commitment to the program is genuine throughout the organization. The training has been updated periodically since its initial development to include the latest research or information about the prevention of track buckling.

UNION PACIFIC TRACK BUCKLING PREVENTION PROGRAM

The following description is from a Union Pacific Chief Engineer's (CE) Instruction Bulletin (I) on track buckling. The

bulletin is based on the research and experience previously outlined.

The importance of this information is that track buckling or sun kinks are not acts of God that cannot be controlled. Track buckling is an extraordinary circumstance that can and must be prevented. Compliance with the nine preventive measures discussed next will ensure that sun kinks and pull-aparts are eliminated. The immense benefits to the safety and efficiency of Union Pacific's operation are certainly worth the extra care taken in the prevention of track buckling.

When and Where Does a Track Buckle?

1. The vast majority of all sun kinks occur on hot, sunny afternoons, usually between 2 and 6 p.m. An ambient (air) temperature of 80°F on a calm, sunny day results in a rail temperature of approximately 100°F. Ambient temperatures in excess of 100°F can result in rail temperatures as high as 140°F.

2. Eighty percent of all sun kinks occur in the late spring or early summer. Most occur in April and May, primarily during the season's first hot spell when there are large variations between daytime high and nighttime low temperatures. The problem persists through June and July when the annual peak temperatures are usually first reached.

3. Track buckling is most likely to happen where major track maintenance work, such as tie renewals, undercutting, sledding, plowing, or surfacing and lining, was recently performed. The lateral resistance of track that has been disturbed by one of these means is reduced by more than 50 percent.

4. Sun kinks frequently occur at locations at which substandard track work was performed. An incomplete and improper rail anchor pattern or insufficient ballast section can directly result in a reduction in the longitudinal and lateral holding power of the track, and a lowering of the neutral temperature of the rail.

5. The majority of track buckling occurs in an area in which CWR has been laid. Much buckling occurs where rail has been laid or repaired during the late fall, winter, or early spring. Improper temperature control when rail is laid, or addition of rail during repair of service failures, replacement of detector car defects, or pull-aparts during cold weather can greatly lower the neutral temperature of the rail.

6. Buckling is more likely to occur in track with poor surface and alignment than in track with good surface and line. Minor surface and alignment defects, especially corrugated rail, which increases dynamic loading, coupled with low neutral temperatures can lead to progressive buckling, particularly on sharp curves.

7. More buckling occurs on curves than on tangent track, however buckling on tangent track is usually more severe. Curves almost always buckle outward (C shape), whereas tangent track generally buckles in both directions (S shape). Many sun kinks occur on curves that were surfaced and lined during the winter months and inadvertently lined in (shortened), resulting in a lowering of the neutral temperature of the rail.

8. Much track buckling occurs at the bottom of grades in areas of heavy braking adjacent to road crossings, turnouts, platforms, bridges, and spots of cemented ballast where the

rail tends to bunch, thus lowering the neutral temperature of the rail. Running rail or tie movement in a loose ballast section at any of these locations dramatically increases the possibility of buckling.

9. Most buckling happens under a train, with a large percentage occurring under the rear half of the consist. Dynamic forces significantly increase buckling potential. This instability is due to the uplift in the track between the front and rear trucks of a car as related to the bending wave character of the rail, the influence of repeated, heavy wheel impacts on the rail under long trains, and the raising of the rail temperatures (by as much as 20°F) caused by friction between the steel wheels and steel rail. Locomotives and heavy trains can also push or pull rail, especially in heavy traction or on grades, which can increase rail compression and shift neutral temperature.

10. Poor train handling contributes to many sun kinks. The braking action of a train changes the longitudinal forces in the track and can cause significant shifts in the neutral temperature of the rail. Slack adjustments in the train can produce extremely high lateral forces on the rail. Improper train handling in areas where track work was recently performed greatly increases the probability of a sun kink, particularly on grades or in curves.

What Must Be Done To Prevent Buckling?

Ballast Section and Rail Anchor Pattern

A standard ballast section and rail anchor pattern must be maintained. The resistance of the track to longitudinal movement is determined by the lower of either the ballast resistance or the anchor resistance. Simply put, a full ballast section minimizes the possibility of creeping ties and a standard anchor pattern reduces the risk of rail movement. A full ballast section is also required to maximize the lateral resistance of the track. Eighty percent of lateral holding power attributable to ballast resistance is concentrated at the bottom and sides of the ties (with full cribs), and the remaining 20 percent is provided on the ends of the ties (12-in. shoulder). Little additional lateral resistance is obtained by increasing the shoulder width beyond 12 in.

Temperature Control

Continuous welded rail (CWR) and jointed rail must be temperature controlled when installed. Jointed rail must be laid with the proper expansion provided between rail ends. CWR must be laid at the temperature prescribed by the chief engineer for the territory involved. The approved minimum installation temperature for CWR is usually 40 to 45°F above the mean annual temperature for the area and varies from 90°F in some cold, mountainous territories to 115°F in some hotter territories.

The neutral temperature of CWR tends to shift downward toward the optimum ambient temperature with time, because of a number of factors that affect the length and stability of the track, such as surfacing and lining, repairing rail defects, derailment and flood reconstruction, switch installations, run-

ning rail and track creep, dynamic forces, and the like. Low neutral temperatures result in extremely high compressive forces in the rail in hot weather, dramatically increasing the possibility of track buckling. This situation must be corrected by cutting out rail to increase the neutral temperature. However, it is important to field-weld these cuts to prevent pull-aparts when the rail is in extreme tension during the winter months.

Rail Repairs in Cold Weather

Service-failed rails, detector car defects, pull-aparts, and other rail repairs undertaken on CWR during cold weather must be accomplished without adding rail. That is, the length of the rail installed to repair the defect must not exceed the length of the rail removed from the track. Sufficient anchors must be removed in both directions from the side of the tie away from the joint(s) to allow rail movement toward the joint(s) only, and then the gap at the joint(s) must be closed using rail expanders, rail heaters, or oil-soaked fiberglass rope placed along the base of the rail and ignited. Once the gap is closed, the rail must be box anchored (every tie) at least 195 ft in each direction from all joints. Standard or compromise joints must be field-welded and insulated joints glued as soon as possible to eliminate the possibility of a pull-apart. The length of the field weld, 1 or 2 in. per weld, must be cut from the rail in track or subtracted from the length of rail to be installed to ensure that rail is not added.

When it is impossible to make repairs as outlined above and rail must be added, the location must be recorded and reported to the track maintenance manager, who must monitor the location as the weather warms in the spring and, at the first sign of any tight rail conditions, must arrange to cut out at least the amount of rail that was added.

Rail in Curves

CWR curves must not be lined in (shortened) unless rail is cut out to compensate for the reduction in neutral temperature. Lining a curve in (i.e., toward the low rail) shortens the curve, resulting in a lower neutral temperature and higher compressive forces in the rail during hot weather. This is particularly critical when surfacing and lining a curve during cold weather with a production tamper or lining with a production liner, since the tamper/liner automatically smooths the curve in when the rail is in tension.

Curves lined in the winter months must be recorded by the track maintenance manager and monitored as warm weather sets in, to ensure that tight rail conditions do not develop. Tight rail in curves can be minimized by lining curves to stakes and balancing the throws. Tight rail in curves can be corrected by lining the curve out or by cutting out excess rail. Good surface and line is particularly important in the prevention of progressive buckling in sharp CWR curves because poor surface and minor alignment imperfections, coupled with low neutral temperatures, can initiate growth to critical levels. Badly corrugated rail in curves also contributes to the problem of progressive buckling and must be corrected by out-of-face grinding or relay of the rail.

Slow Orders

Undercutting, sledding, plowing, surfacing, lining, tie installation, track construction, track rehabilitation or restoration, and any other type of track work undertaken in hot weather that disturbs the roadbed or ballast section must be protected with an appropriate slow order until the ballast section has consolidated under traffic. Consolidation under at least 125,000 gross tons of train traffic is required to restore roughly 50 percent of the lateral resistance lost during surfacing and lining operations (i.e., restoration to 75 percent of original strength). Passage of at least 1 million gross tons (1.0 MGT) is required to re-establish almost all of the original holding power of the track. The chief engineer's instructions spell out the minimum requirements for slow ordering track when track work is performed during hot weather. However, more restrictive measures, such as slower speeds, longer order limits, or longer time limits must be taken when conditions such as a substandard ballast section, insufficient anchor pattern, incomplete spiking, heavy grades, sharper curvature, or proximity to fixed facilities (e.g., bridges, switches, platforms, or road crossings) warrant additional protection. Ordinary or spot track maintenance work that disturbs the track structure should be avoided on CWR during hot weather, to the extent practical.

Inspection

Main lines and sidings must be inspected frequently during hot weather, primarily to detect tight rail conditions in order to take corrective action before the track buckles. Inspection is particularly critical during the first hot spells in the spring (80°F plus) and during extremely hot weather (90°F plus) thereafter. Inspection for tight rail and sun kink locations is most effective between noon and 7 p.m. on hot, sunny days. The inspector should look for extremely kinked or "nervous" rail that is riding up or out of the tie plates or is crowding the shoulder of the plates. The inspector should also look for clusters of high spikes or bad ties, tie movement in the ballast as evidenced by bunching or lack of the ballast at the end of the ties, and running rail as evidenced by anchors not tight against the tie or by shiny marks on the base of the rail where the rail has slipped through the anchors or spikes. An appropriate slow order must be placed until the condition is corrected.

Known tight rail locations can be cut with a saw in the morning while the rail is still cool and in tension. However, extremely tight rail discovered in the heat of the day requiring immediate corrective action will have to be cut with a torch. (Rail in extreme compression will pinch the saw blade, thus precluding the use of a saw for the initial cut.) Rail cut with a torch must then be recut with a rail saw at least 3 in. from the torch-cut ends to eliminate brittle martensite from the ends of the rail. Therefore, at least 6 in. of excess rail must be removed from the track or a replacement rail (15-ft minimum length) must be cut in if removal of less than 6 in. is desired. All cuts must be field welded as soon as practical to prevent rail-end batter and to preclude the possibility of pull-aparts in the winter. The important thing to remember concerning tight rail is "If in doubt, cut rail out."

Temperature Restrictions

Preventive blanket speed restrictions must be applied during extremely hot weather. When ambient temperature reaches or exceeds temperatures shown in Table 1, all trains are restricted as shown in Table 2. In the spring or early summer when the ambient temperature first reaches a daily peak temperature 5° below the temperatures shown in Table 1, the restrictions presented in Table 2 apply. The blanket heat orders will continue to be applied at the 5° lower level for five consecutive days, after which the effective temperature of the blanket heat order may be raised to the maximum level shown in Table 1.

Track maintenance managers and track inspectors must inspect their main tracks via Hy-rail or automobile during the heat of the day when the blanket heat orders are in effect, looking primarily for tight rail and substandard track conditions. The blanket speed restriction guidelines outlined in Instruction Bulletin (I) are minimum requirements, and more restrictive measures must be taken when conditions warrant

them. Specific tight rail locations must be restricted to as slow a speed as necessary to prevent track buckling and derailments until the rail can be destressed by being cut to relieve the high compressive forces.

Track maintenance managers are responsible for placing blanket speed restrictions on their respective territories. When instructing train dispatchers to issue track bulletins because of extremely hot weather, track maintenance managers must advise the train dispatcher whether the Level 1 or Level 2 heat restriction applies, and the time and location where the track bulletin is to be in effect. There are two general types of time limits for placing the heat restriction in effect:

1. On a day when it is anticipated that the ambient temperature will reach the previously indicated threshold levels, the train dispatcher should be notified in advance (usually in the morning or the night before) that the restriction is to take effect.
2. On a day when it is anticipated that the ambient temperature will not reach the aforementioned threshold levels,

TABLE 1 TEMPERATURE TABLE FOR BLANKET SPEED RESTRICTIONS

STATE	SUBDIVISION/BRANCH	STATIONS	TEMP
CALIFORNIA	LOS ANGELES	YERMO-DAGGETT	105°
		RIVERSIDE-LOS ANGELES	100°
	CIMA	BORAX-YERMO	105°
	OAKLAND	ENTIRE SUBDIVISION	95°
	CANYON	STOCKTON-JAMES JAMES-PORTOLA	95° 90°
	WINNEMUCCA	ENTIRE SUBDIVISION	90°
	BIEBER	ENTIRE BRANCH	90°
NEVADA	ENTIRE STATE		90°
EXCEPT	CALIENTE	CRESTLINE-ISLEN	95°
		ISLEN-LEITH	100°
		LEITH-LAS VEGAS	105°
	CIMA	LAS VEGAS — BORAX	105°
UTAH	ENTIRE STATE		90°
EXCEPT	CALIENTE	UVADA-MILFORD	95°
IDAHO	ENTIRE STATE		90°
OREGON	ENTIRE STATE		90°
WASHINGTON	ENTIRE STATE		90°
WYOMING	ENTIRE STATE		90°
NEBRASKA	ENTIRE STATE		90°
COLORADO	ENTIRE STATE		90°
EXCEPT	HOISINGTON	ENTIRE SUBDIVISION	95°
KANSAS	ENTIRE STATE		90°
EXCEPT	COUNCIL GROVE	ENTIRE SUBDIVISION	95°
	HOISINGTON	ENTIRE SUBDIVISION	95°
	WICHITA	ENTIRE SUBDIVISION	95°
	MCPHERSON	ENTIRE BRANCH	95°
	ENTIRE STATE		95°
ILLINOIS	CHICAGO	SALEM NORTH	90°
	PANA	ENTIRE SUBDIVISION	90°
	ENTIRE STATE		95°
MISSOURI	ENTIRE STATE		95°
OKLAHOMA	ENTIRE STATE		100°
ARKANSAS	ENTIRE STATE		100°
LOUISIANA	ENTIRE STATE		100°
TEXAS	ENTIRE STATE		100°
NEW MEXICO	ENTIRE STATE		100°
TENNESSEE	ENTIRE STATE		100°

Covering main lines and branch lines with maximum operating speeds more than 40 mph.

TABLE 2 SPEED RESTRICTIONS APPLIED DURING HOT WEATHER

Type of Train	Speed Restriction (mph)
Level 1 Heat Restriction^a	
Passenger trains, light engines, trains with symbol Z that are 5,000 tons or less, and unit double stack trains that are 5,000 tons or less.	None
Trains with symbol Z more than 5,000 tons and unit double stack trains more than 5,000 tons.	60
All other trains averaging less than 90 tons per car or platform.	50
All other trains averaging 90 tons or more per car or platform.	40
Level 2 Heat Restriction^b	
Freight trains averaging 90 tons or more per car or platform.	40
All other trains (including light engines).	50

NOTE: The Level 1 and 2 heat restrictions may be found in Union Pacific Railroad Timetable No. 7, Special Instructions, Oct. 29, 1989, p. 120.

^aTo be used when ambient temperature is up to 10°F above the temperature shown in Table 1.

^bTo be used when ambient temperature is 10°F or more above the temperature shown in Table 1.

but the levels are subsequently reached, the track bulletin should be issued to take effect immediately.

Unless unusual conditions exist, both of these general types of time limits should be lifted at 9:01 p.m. without issuance of another track bulletin. The removal time of 9:01 p.m. should not be subsequently shortened unless the temperature drops significantly later in the day, in which case the track bulletin can be cancelled before 9:01 pm. All engineering officers, managers, and supervisors must continually monitor the status of track bulletins placed on their territories to ensure that these instructions are appropriately applied. Heat restrictions may be applied at lower temperatures or lower maximum speeds may be specified if, in the judgment of the track maintenance manager, conditions such as heavy grades, sharp curvature, insufficient anchor pattern, substandard ballast section, tight rail, and so forth warrant additional protection to ensure the continued safe operation of trains.

Extent of Speed Restrictions

Speed restrictions placed because of track work must be enforced beyond the limits of the work to ensure that trains have slowed to the desired speed before entering the area of the unstable track. Heavy braking actions and slack adjustments must be made before encountering the newly worked track to minimize track bunching and rail running, and to reduce the dynamic forces created by the movement of the train over the track. Under normal conditions, slow orders should extend at least ¼ mi in each direction from the outside limits of the newly disturbed track. Heavy grades and sharp curves may warrant additional slow-order lengths, particularly where substandard track conditions are present.

Reporting

If a sun kink does occur, it must be reported on the standard form even if the buckling did not result in a derailment. Proper reporting is essential in order to identify problems and trends; thus, it is important that all the information required be completely and accurately reported. This information is then used in developing necessary preventive programs.

UNION PACIFIC RAILROAD PROCEDURES

The following are additional instructions provided to Union Pacific dispatchers, locomotive engineers, and others to help in understanding how the information loop is closed within the Union Pacific Operating Department.

Office Bulletin OB-04-28-89TT 6 STS

Office Bulletin OB-04-28-89TT 6 STS, issued to all dispatchers and officer personnel, reads as follows (2):

Air Brake and Train Handling Rule 1104(C) is now in effect. This rule was written to help prevent derailments caused by track buckling. Rule 1104(C) is intended to be imposed at locations where Engineering forces have performed work disturbing the track structure in such a manner that the risk of track buckling is increased. This rule was designed to be implemented at the discretion of the Manager Track Maintenance (MTM) or supervisor in charge of work and used in conjunction with the speed restriction placed on the disturbed track. Before calling in a track restriction to the dispatcher's office, the MTM or supervisor will evaluate the type of work performed, temperatures expected, and other conditions to determine if implementation of Rule 1104(C) is necessary for that location.

When requested by MTM or Supervisor in charge of work to issue track bulletin due to extreme heat, train dispatcher will be furnished necessary level of heat restriction (Level 1 or 2), time limits, and location limits the track bulletin is to be in effect. Train dispatcher will then make track bulletin as shown below, adding necessary information, and issue to all trains affected:

Level (1 or 2)
HEAT RESTRICTION APPLIES AS PRESCRIBED BY
GENERAL ORDER
BETWEEN (time) AND (time)
BETWEEN (Location) AND (Location)

With Rule 1104(C) in effect, slower running time through a speed restriction may be expected.

Air Brake Rule 1104(C)

Air Brake Rule 1104(C), issued to all train crews, reads as follows (3):

Track bulletins or other instructions from proper authority may be issued stating that engineers handle their train in accordance with Air Brake Rule 1104(C) between the stated limits. When proceeding through the limits of the track bulletin or where so instructed, the engineer must handle the train so that track and structures within those 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 adjustment, moderate

to high draft or buff forces, and heavy train braking. These forces are minimized when the engineer uses throttle modulation or low dynamic brake amperage, makes no slack adjustments, and uses no automatic brake while controlling speed through the restriction. To the extent practicable, 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 minimizing buff or draft forces while carefully controlling speed as the train is passing through the restriction.

Instructions for Locomotive Engineers

Instructions to all Locomotive Engineers reads as follows (4):

The air brake and train handling Rule 1104(C) is designed to prevent Track Buckling (Sun Kinks) from occurring ahead of or beneath your train. When conditions merit, this rule will be used in conjunction with track bulletins that have been issued where engineering is or has been working on the track. It will most frequently be applied at locations where high rail temperatures occur.

Where a temporary speed restriction is set by track bulletin, it is the maximum speed trains are allowed over the limits of the restriction. This does not mean that you are expected to maintain that speed no matter what. There is, in fact, no minimum speed through this type of order. There is nothing wrong with proceeding through a slow order well under the speed limit. There may be times where the best way to reduce train generated forces is to proceed very slowly. There may even be times when you will need to allow the train to come to a full stop, such as avoiding the excessive force buildup which can occur when making running releases. There are numerous other methods for reducing in-train forces, allowing speed to drift up by entering the restriction at low speed, allowing speed to drift down after entering at the speed of the restriction, using an air brake/dynamic brake balance in place of dynamic brakes only, or even using a little power against air to maintain a uniform speed and force. Heavy braking in or approaching disturbed track must always be avoided because the braking forces are trying to push the rail ahead and may cause disturbed track to buckle. Heavy dynamic or engine braking must also be avoided for the same reason. Remember that light forces spread evenly throughout the train are much better than a heavy and concentrated force.

When ascending a grade through a restriction, the most desirable technique would be to enter the restriction at the speed you are allowed. As the engines pass over the disturbed track, gradually reduce the power, allowing speed to reduce slightly, but not so much that your train will stall before it clears the restriction. As the locomotive clears the restriction, you may gradually increase the throttle to bring your speed back up to that allowed until the remainder of your train clears the restriction. This method allows energy stored in the train to partially maintain your momentum while reducing the head-end draft forces. This is also a good method to use on level track when the restriction is in a curve. Take care not to shut off so much or so fast that the train stalls or slack runs in. When using this procedure on level track, prepare your train well in advance so that all train brakes are fully released and

the power is uniform throughout the train. When practicable, avoid making power changes while the locomotive is in the restriction.

On a slight descending grade where the automatic air is not needed and the dynamic brake is in use, enter the restriction at a slower speed than the restriction allows. Then, gradually reduce the dynamic brake, allowing a slight acceleration, but not enough to allow the speed to go above authorized speed. As the locomotive clears the limits, increase your dynamic enough to prevent the speed from going above that authorized. On heavy descending grade, use a balance of dynamic brake and train brakes. Make minimum or split service reductions sufficiently ahead of the restriction to ensure propagation of braking has ceased before the head-end enters the restriction. If speed drops, gradually reduce the dynamic to allow the train to continue to roll. If the air brakes and dynamic is too much retarding force, gradually reduce the dynamic. If necessary, ease the dynamic off completely and work light power to maintain your speed. These operating practices, as well as others you may commonly use, will allow you to comply with the intent of Rule 1104(C). The professional locomotive engineer has a considerable repertoire of train handling techniques.

Avoiding track buckles by reducing the forces transmitted to the track is in the hands of the locomotive engineer. Control of the power, automatic brake and the dynamic brake in compliance with Rule 1104(C) is the best way of avoiding a track buckle. If any of the operating practices discussed here are not familiar to you or if you have other questions regarding the intent or application of this rule, you should contact your Manager of Operating Practices. With your help, track buckling derailments can be eliminated.

CONCLUSION

From 1988 to 1989 the Union Pacific reduced total derailment costs by approximately \$25 million. A major factor in this reduction was the improvements made in the area of reduced track buckling derailments.

Year	No. of Buckling Occurrences	Total Derailment Costs (\$) Plus Additives
1988	11	3,731,000.00
1989	3	70,000.00

These statistics emphasize the benefits of having an effective and vigorously enforced track buckling prevention program in place.

REFERENCES

1. *Instruction Bulletin CE-88-006-T*. Union Pacific Railroad, Omaha, Nebr., 1988.
2. *Office Bulletin OB-04-28-89TT 6 STS*. Union Pacific Railroad, Omaha, Nebr., 1989.
3. *Air Brake Rule 1104(C): Train Handling Over Disturbed Track*. Union Pacific Railroad, Omaha, Nebr., n.d.
4. *Instructions to all Locomotive Engineers*. Union Pacific Railroad, Omaha, Nebr., April 28, 1989.