National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: August 15, 2003

In reply refer to: R-03-06 through -08

Mr. Michael J. Ward
President
CSX Transportation, Inc.
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Jacksonville, Florida 32202

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable causes, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

These recommendations address continuous welded rail (CWR) temperature control; CWR restraint, including ballast and rail anchors; and CWR maintenance procedures and standards. The recommendations are derived from the Safety Board's investigation of the derailment of National Railroad Passenger Corporation (Amtrak) Auto Train P052-18 on CSX Transportation (CSXT) track near Crescent City, Florida, on April 18, 2002, and are consistent with the evidence we found and the analysis we performed.[1]

About 5:08 p.m. eastern daylight time on April 18, 2002, northbound Amtrak train P052-18, the Auto Train, derailed 21 of 40 cars on CSXT track near Crescent City, Florida. The train derailed in a left-hand curve while traveling about 56 mph. The train was carrying 413 passengers and 33 Amtrak employees. The derailment resulted in 4 fatalities, 36 serious injuries, and 106 minor injuries. The equipment and track costs associated with the accident totaled about $8.3 million.

The Safety Board determined that the probable cause of the derailment was a heat-induced track buckle that developed because of inadequate CSX Transportation track-surfacing operations, including misalignment of the curve, insufficient track restraint, and failure to reestablish an appropriate neutral rail temperature.

As a result of its investigation of this accident, the Safety Board has issued eight safety recommendations, three of which are addressed to CSXT. Information supporting the

[1] For additional information, see National Transportation Safety Board, *Derailment of Amtrak Auto Train P052-18 on the CSXT Railroad Near Crescent City, Florida, April 18, 2002*, Railroad Accident Report NTSB/RAR-03/02 (Washington, DC: NTSB, 2003).

recommendations is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

The events that led to the development of a track buckle at the derailment location had evolved for more than a year prior to the accident and concerned the track conditions at the accident curve, as well as the track maintenance activities that took place at and near this site. Specifically, the investigation indicated that the roadbed width of the track on the curve embankment, the ballast condition of the track, the rail anchoring in the area, the surfacing operations undertaken by CSXT at this location, and the rail temperature practices used during and after the surfacing operations all contributed to the track instability that allowed the track buckle to form. Individually, perhaps none of these factors would have generated the track buckle; in combination, they created the unstable track environment conducive to the sudden development of a buckle on April 18, 2002.

The CSXT standard engineering plan for new roadbed requires a 30-foot-wide roadbed. CSXT does not have a specific roadbed width maintenance requirement; instead, it requires roadbeds to be maintained so that they adequately support the ballast section. Based on the known tie dimensions and CSXT track standards for existing track, Safety Board investigators calculated that the minimum roadbed width for the track on the accident curve, assuming it met the established CSXT standards, was 15 feet.[2] Visual evidence indicated that the roadbed in the accident curve was likely narrower than this minimum.[3]

The CSXT chief regional engineer for the Jacksonville District stated that the area of the derailment had a relatively narrow roadbed. He also stated that in some cases, CSXT "roadbeds become narrow because we continue to elevate the track by surfacing our track and raising the track structure." Because the roadbed in the accident curve had narrowed so that it could not adequately retain the normal ballast profile, ballast migrated down the inside slope of the embankment in the months before the accident, necessitating repeated resurfacing operations.

Despite the narrow roadbed, it appears that the ballast had not begun to migrate significantly until early in 2001. In fall 2000, about 18 months before the accident, CSXT had conducted shoulder ballast cleaning operations through the accident curve, in an effort to improve track drainage. The shoulder ballast cleaning removed fouled ballast from the shoulder area of the track, cleaned the ballast, and returned the cleaned ballast to the shoulder. However, according to the local CSXT track supervisors and inspector, in the months after the cleaning, ballast began migrating down the inside of the curve embankment. Evidently, by breaking up the

[2] The ballast depth dictates the length of the 2:1 ballast shoulder slope. Because the ties were 7 inches deep and the minimum ballast depth beneath the ties was 8 inches, the ballast profile depth was 15 inches. Thus, a 2:1 ratio means the length of the ballast shoulder slope was 30 inches on each side of the track. According to CSXT standards, the inside curve ballast shoulder width should have been 6 inches and the outside curve ballast shoulder width should have been 12 inches. The length of a tie was 8 feet, 6 inches, or 102 inches. Therefore, the minimum roadbed width necessary to support the CSXT ballast shoulder profile for the accident curve was 30+6+102+12+30 inches = 180 inches, or 15 feet.

[3] Because the derailment forces largely destroyed the roadbed and track in the immediate area of the accident, investigators could not measure the roadbed at this location after the accident took place. However, investigators examined the roadbed immediately preceding and beyond the derailment site.

hardpan soil supporting the ballast, the cleaning process had freed the ballast and allowed it to move down the inside of the curve embankment.

Adequate ballast is crucial to ensuring the track's lateral support and restraint. Because of the track's narrow roadbed and the consequent ballast migration, CSXT could not maintain sufficient ballast around the ties and rail at the roadbed track level at the top of the embankment to provide adequate support and restraint. In an attempt to halt ballast migration down the inside slope of the accident curve, CSXT constructed a ballast-retaining wall of used concrete ties on March 6, 2002, about 6 weeks before the accident occurred. The CSXT track inspector for this area acknowledged that before the installation of the ballast-retaining wall, the ballast levels supporting the track at the accident curve were not sufficient to meet CSXT standards. In particular, with respect to the shoulder ballast, he stated, "It wasn't maintained to [CSXT] standards with the 12 inches of ballast on the high side and 6 inches on the low, two-to-one."

Safety Board investigators inspected the track adjacent to the derailment site after the April 18, 2002, accident and found that in many places the ballast did not fill the tie cribs between the crossties. Many cribs were only half full in the center and even less full toward the ends. Investigators found little or no ballast off the ends of the ties, let alone a full ballast shoulder up to the tops of the tie ends. Therefore, the Safety Board concluded there was insufficient ballast on the accident curve prior to the accident to meet CSXT's own standards and to ensure that the CWR was being adequately restrained.

In August 2002, the Federal Railroad Administration (FRA) conducted a focused inspection of all CSXT track on which Amtrak trains and commuter rail traffic operate. According to the final FRA report, of the 4,770 CSXT route miles the FRA inspected, 511 track miles did not conform to CSXT's own ballast section requirements.

Issues concerning CSXT rail anchoring also arose during the investigation. Rail anchoring restricts the longitudinal movement of the rail, which localizes the compressive or expansive forces in the rail so that these forces are distributed uniformly throughout the track structure. Postaccident inspection of the undamaged track north and south of the derailment site revealed a number of locations where rail anchors were missing or where rail anchors were not snug against ties. Nineteen percent of the rail anchors required through the accident curve were determined to be missing or not snug against ties.

A rail anchor that is not snug against the tie allows longitudinal rail movement in one direction to the extent of the distance or gap between the tie and the anchor. Longitudinal rail movement may be due to thermal expansion, which is a function of rail length. The free expansion or contraction in a 3-foot length of rail with a 50° F difference in rail temperature throughout a day would be about .008 inch. (In a 1/4-mile length of rail, this would total about 3 1/2 inches.) Therefore, to adequately restrain the rail, a rail anchor must be snug against a tie, because if the gap between the tie and anchor is (as in the cited example) greater than .008 inch, theoretically, the anchor would never contact the tie or provide any restraint. Thus, a rail anchor that is not snug against a tie is unlikely to provide significant rail restraint. The American Railway Engineering and Maintenance-of-Way Association, rail anchor manufacturers, and industry experts agree that for rail anchors to be effective, they should be against the tie. In the rail anchor standard in its Maintenance Bulletin MWI 1113-01, *Performance for Large Scale*

Track Work, CSXT states that anchors not snug against ties constitute a defect. The Safety Board concluded that missing rail anchors and ineffective rail anchoring contributed to track instability through the accident curve.

Although the FRA does not have a minimum requirement for the number of effective anchors for CWR track, CSXT has, as noted above, established its own rail anchoring standards. However, only CSXT's large system-wide track maintenance production teams are required to adhere to the anchoring standards in Maintenance Bulletin MWI 1113-01. Because CSXT does not require its local maintenance-of-way crews to use such standards, they typically rely on the experience and judgment of local supervisors, which might not be adequate to ensure a safe track condition. Therefore, the Safety Board believes that CSXT should require all track maintenance employees, including large system-wide track maintenance team members and local maintenance-of-way crew members, to use a consistent rail anchor standard that includes a requirement that rail anchors be maintained snug against ties.

The track surfacing procedures used on the accident curve also raised concerns. On October 9, 2001, regional CSXT surfacing gang members began to surface the full curve from MP 722.5 to MP 722.1, working from south to north. While working on the northern end of the curve and into the north curve spiral, they realized that the track liner-tamper machine they were using was not lining the track properly. By manually adjusting the machine, they were able to finish surfacing the curve. Two days later, on October 11, after the liner-tamper was repaired, the surfacing gang members used it to re-line and tamp the track from the point at which they estimated the machine had first experienced problems and continued north through the rest of the curve and spiral. The gang members did not record the exact location at which the liner-tamper machine went out of alignment, nor did they document the exact location at which the machine was subsequently restarted 2 days later. Therefore, the repaired liner-tamper machine may well have been started at a point in the curve beyond where the machine had actually first deviated, which would have resulted in a discontinuity in the constant smooth transition of the curve and the introduction of a slight deviation or "notch" in the curve that provided a weak point in the track.

This area of the track was repeatedly machine-surfaced in the months before the accident. On November 19, 2001, the surfacing gang machine-surfaced portions of track on the northern section of the curve. On February 26, 2002, the curve was machine-surfaced from MP 722.3 to MP 722.1; and on March 11, 2002, the curve was machine-surfaced from MP 722.3 to MP 722.2. At no time during these surfacing processes was the curve measured or checked against a reference point to ensure that the alignment was correct or that a smooth transition was maintained.

If an alignment deviation was introduced somewhere near the middle of the curve during the work on October 11, 2001, the subsequent surfacing operations would not have corrected it. The deviation would have remained a weak point in the curve alignment. Given that surfacing work is recorded to the nearest 1/10th of a mile, it is reasonable to suppose that the point of derailment, MP 722.24, fell within the weak anomaly area introduced on October 11, 2001.

Therefore, the Safety Board concluded that the problems with the liner-tamper machine on October 9, 2001, and the re-implementation of the repaired machine well into the curve on

October 11 introduced a track misalignment and caused a weak point in the curve that was susceptible to later buckling. On July 31, 2002, CSXT issued Track Bulletin 005, notifying its track maintenance workers that if a liner-tamper machine broke down during a surfacing operation in a way that "adversely affected the quality of the raising, aligning or ballast compaction," they should (among other requirements) check and, if necessary, resurface the entire curve.

The investigation indicated that CSXT did not ensure the maintenance of an appropriate neutral rail temperature for the accident curve. Track buckling occurs when the difference between the current rail temperature and the neutral (force-free) rail temperature creates thermally induced internal longitudinal rail forces strong enough to overcome the track's lateral restraint. These thermally induced forces will accumulate at the weakest point in the track, which will create a track buckle when the lateral restraint is overcome.

To determine what conditions led to the development of the track buckle at the Crescent City curve, it was necessary to establish the current rail temperature when the track buckle developed. Although no one measured the rail temperature at the accident curve around 5:00 p.m. on April 18, 2002, when the track buckle likely developed, meteorological reports indicate that the ambient temperature about that time was in the low 80s (° F), and the day was mostly sunny. When the rail temperature was measured 2 days after the accident, during the late afternoon of April 20 (a partly sunny day), the rail temperature at the accident site area was 120° F at a time when the ambient temperature was in the high 80s (° F). On April 24 (a partly sunny day) at 5:00 p.m., the ambient temperature was 83° F, and the rail temperature was 108° F. Given that the ambient temperature on April 18 was similar to that on April 24, a neutral rail temperature of at least 108° F seems likely. In addition, April 18 was a mostly sunny day while April 24 was only partly sunny. The cumulative effect of hours of nearly continuous sunshine on metal rail by late afternoon on the day of the accident likely increased the rail temperature by a further significant increment. Therefore, it seems probable that the rail temperature about 5:00 p.m. on the day of the accident was well above 108° F. A current rail temperature of between 110° and 120° F is entirely feasible.

The CWR-SAFE computer program,[4] which determines the "allowable temperature increase" for buckling prevention and the buckling safety margin, indicated that CWR may buckle when the difference between the neutral rail temperature and the current rail temperature is 50° F or more, depending on the condition of the ballast and track structure.[5] For the Crescent City accident curve, the CWR-SAFE program predicted a neutral rail temperature for buckling of between 60° and 65° F.

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[4] To determine if a track buckle was feasible in the accident curve under the conditions at the time of the derailment, the Safety Board asked the Volpe Center in Cambridge, Massachusetts, to perform a track buckling analysis with a computer software program called "CWR-SAFE," which had been developed for the FRA. The computer program determines the "allowable temperature increase" for buckling prevention and the buckling safety margin. CWR-SAFE also includes a program for risk-based buckling safety evaluation, with the key output being "probability of buckling versus rail temperature." The Safety Board provided Volpe with factual track information to formulate the parameters for the buckling analysis.

[5] The better the track structure, the greater the difference in temperature the track can withstand. Conversely, the weaker the track structure (particularly if it is deficient in ballast), the less rail temperature change the track can withstand before buckling.

Given a neutral rail temperature of 60° to 65° F and an increase in rail temperature of 50° F, the resulting current rail temperature of around 115° F on the afternoon of the accident could have resulted in a track buckle. Consequently, investigators attempted to determine how a neutral rail temperature in the 60° to 65° F range might have developed for the rail in the accident curve.

Numerous maintenance operations were performed in the accident area in the 6 months before the derailment. The repeated surfacing operations have already been noted. These maintenance operations were carried out in the cooler months of the year, when rail temperatures were well below the CSXT neutral rail temperature standard of 100° F. No rail adjustments were performed after these maintenance operations broke the bond between the ballast and the ties. (Under these conditions, appropriate rail adjustment according to CSXT procedures would have consisted either of removing the rail anchors, heating the rail, and then reanchoring it, or of realigning the curve.)

Proper rail temperature control is critical during the period immediately after the track has been disturbed and until the track is reestablished and firmly stabilized in the ballast. On February 26, 2002 (about 7 weeks before the accident), the CSXT regional surfacing gang machine-surfaced the track segment from MP 722.3 through MP 722.1, which encompassed the point of derailment (MP 722.24). The rail temperature was measured at 90° F when the work was completed on February 26.

After this surfacing, the ambient temperature in the area decreased for the next 3 days while the track was in the post-surfacing stabilization process. The following were the daily high and low ambient temperatures from February 26 through March 1:

February 26	75° F	45° F
February 27	68° F	36° F
February 28	55° F	36° F
March 1	66° F	48° F

The track was exposed to a range of relatively low temperatures during the 3-day period following the February 26 surfacing, while the track was most subject to movement.[6] Temperatures during this period were in the 60s (° F) and lower, making the CWR-SAFE criteria of a 60° to 65° F neutral rail temperature not only feasible but probable.

Adequate ballast could have helped to restrain, if not prevent, the rail from significantly contracting. Given the lack of ballast, which would have allowed the track to move with relative ease, the rail could have contracted to a low neutral rail temperature, causing the curve to "chord" (shrink) inward, which would have made it prone to buckle when the weather warmed. When about 70 tons of ballast was dumped on the north end of the accident curve on March 8, the rail had already had ample time (10 days) to contract to a new and lower neutral rail temperature without sufficient ballast restraint. Because the track in the curve did not have sufficient ballast, it was inadequately restrained after being disturbed on February 26. CSXT and industry maintenance practices for surfacing CWR track recommend that track not be surfaced

[6] A slow order was in effect for MP 722.3 though MP 722.1 from February 5 through March 13, 2002.

until sufficient ballast is distributed to provide the necessary restraint. Insufficient restraint, caused by insufficient ballast, will permit the track to move during stabilization or possibly not to stabilize at all. A later application of ballast, such as CSXT's addition of 70 tons of ballast to the curve on March 8, will not correct this problem, because movement may have already occurred. Therefore, the Safety Board concluded that the accident curve chorded inward because there was insufficient ballast in the track at the time of the February 26, 2002, surfacing to prevent track movement as the track stabilized.

On March 11, the accident curve was resurfaced, this time between MP 722.3 and MP 722.2, a segment containing the point of derailment. The liner-tamper machine started in the body of the curve and moved northward to create a 1-inch lift. The high and low daily temperatures in the days after this surfacing were as follows:

March 11	74° F	53° F
March 12	84° F	56° F
March 13	79° F	54° F
March 14	78° F	54° F

These ambient temperatures were somewhat higher than those in effect during the February 26 through March 1 period but were still well below those needed to achieve the desired neutral rail temperature standard of 100° F. Although less likely than the track disturbed during February 26 to fall to the 60° to 65° F neutral rail temperature range necessary for buckling, the track involved in this surfacing would still have developed significant compressive forces that would tend to further stress a buckle-prone weak point in the curve.

As has been stated, with the decline in ambient temperature that occurred after the February 26 surfacing operation (coupled with the lack of ballast on the curve from February 26 until March 8), the rail contracted and the track chorded inward. To detect track movement, CSXT requires curves over 1 degree in CWR track to be monumented if the temperature falls below 50° F during surfacing. However, CSXT procedures do not require monumenting if the temperature falls below 50° F during the stabilization period following surfacing work. (Monumenting consists of establishing known reference points against which any subsequent movement of the track can be measured.)

The temperature during the February 26 surfacing work was well above 50° F, so the track was not monumented. During the post-surfacing stabilization period, however, temperatures fell below 50° F. When the track was resurfaced on March 11, there was no way to determine whether the track had moved since the February 26 work, because the track had not been monumented on February 26. Therefore, the Safety Board concluded that because the curve was not monumented when it was surfaced on February 26, 2002, the crew resurfacing the track on March 11, 2002, did not know whether the track had moved since February 26, 2002. Had the crew members known the track had moved, they could have adjusted the curve appropriately. Therefore, the Safety Board believes that CSXT should modify its procedures to ensure that when a curve is surfaced, it is also monumented, if local temperatures are predicted to fall below 50° F during the post-surfacing stabilization period.

According to CSXT rules, each time the track is disturbed, a Track Disturbance Report is to be filled out and submitted for later rail temperature reference. At the time of the accident, CSXT required that Track Disturbance Reports be submitted monthly. (Since the accident, CSXT has required that Track Disturbance Reports be submitted weekly.) Roadmasters use the reports to identify areas that need additional attention, particularly when the weather gets warmer. The reports are also used to direct follow-up track adjustment. The CSXT regional surfacing gang foreman, who had performed most of the surfacing operations through the accident curve, admitted that on several occasions he had not submitted the required monthly Track Disturbance Reports after disturbing the track. Consequently, no timely record was available to the roadmaster indicating the necessity of performing appropriate track adjustments following the track disturbances. Also, despite the fact that regional engineering personnel were aware of the surfacing gang foreman's assignments and locations, no one from CSXT ever checked to ensure that the disturbance reports were submitted after the surfacing was done.

According to the roadmaster, local maintenance crews usually start adjusting rail that has been disturbed during the winter season when the ambient temperature rises to approach the upper 80s (° F), which in the Crescent City area typically occurs in April. The temperature on April 18, 2002, reached the low 80s (° F), and temperatures in the mid to high 80s (° F) were experienced in the days after the accident. Thus, when the accident occurred, area temperatures were nearing the range at which track adjustments were normally carried out. Therefore, the Safety Board concluded that had the Track Disturbance Reports been submitted in a timely fashion, the roadmaster might have used them to prioritize the track adjustment work to be carried out on track disturbed during the winter, including the accident curve.

In summary regarding CSXT track maintenance, the Safety Board notes that the Crescent City investigation showed that the CSXT program was inadequate in two general respects. First, CSXT failed to establish some needed track standards. Second, CSXT failed to ensure that its track maintenance workers routinely fulfilled the requirements of its existing track standards.

With reference to the former problem, CSXT did not have adequate requirements at the time of the accident for ensuring effective rail anchoring, for monumenting curves when temperatures were expected to fall below 50° F during the track stabilization period following surfacing, or for relining the entire curve if the liner-tamper machine broke down during a surfacing operation. CSXT has since addressed the liner-tamper procedure deficiency, and the Safety Board has proposed safety recommendations to provide appropriate requirements for rail anchoring and monumenting.

However, the provision of new written requirements in these areas will not solve the underlying quality control problem concerning CSXT track maintenance indicated by this investigation. The Safety Board found that although CSXT had written standards for ensuring the maintenance of an adequate ballast section to restrain the track and for conducting surfacing operations according to established practices and rules (such as drafting and submitting Track Disturbance Reports at specified intervals), CSXT track employees sometimes did not fulfill these requirements. Given these deficiencies, it appears that CSXT did not have an effective quality control program that ensured strict adherence to written track standards among its track maintenance employees. Therefore, the Safety Board concluded that CSXT did not provide adequate oversight to ensure that its track maintenance activities were carried out in accordance with its own standards.

In addition, when the FRA conducted an August 2002 focused inspection of CSXT track used by Amtrak and commuter rail trains, FRA inspectors found numerous instances of track conditions that did not conform to CSXT requirements. The FRA findings, coupled with the repeated failures by CSXT track personnel to fulfill established CSXT track standards and practices revealed during this accident investigation, suggest that CSXT may have a quality control problem with its track maintenance operations, particularly in the area of track surfacing. Therefore, the Safety Board believes that CSXT should develop a systematic quality control program to ensure that track-surfacing personnel consistently conduct track-surfacing operations in accordance with CSXT standards.

Therefore, the National Transportation Safety Board makes the following safety recommendations to CSX Transportation, Inc.:

> Require all track maintenance employees, including large system-wide track maintenance team members and local maintenance-of-way crew members, to use a consistent rail anchor standard that includes a requirement that rail anchors be maintained snug against ties. (R-03-06)
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> Modify your procedures to ensure that when a curve is surfaced, it is also monumented, if local temperatures are predicted to fall below 50° F during the post-surfacing stabilization period. (R-03-07)
>
> Develop a systematic quality control program to ensure that track-surfacing personnel consistently conduct track-surfacing operations in accordance with CSX Transportation standards. (R-03-08)

The Safety Board also issued safety recommendations to Amtrak, the Federal Railroad Administration, and the Transportation Security Administration. In your response to this letter, please refer to Safety Recommendations R-03-06 through -08. If you need additional information, you may call (202) 314-6177.

Chairman ENGLEMAN, Vice Chairman ROSENKER, and Members GOGLIA, CARMODY, and HEALING concurred in these recommendations.

Original Signed

By: Ellen G. Engleman
Chairman