National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: February 3, 2005

In reply refer to: R-05-04

Mr. Charles H. Emely
Executive Director and Chief Executive Officer
American Railway Engineering and Maintenance-of-Way Association
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The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, 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 recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses the effect of bond wire welding on rail integrity and inconsistent instructions regarding the exothermic welding of bond wires. The recommendation is derived from the Safety Board's investigation of the February 9, 2003, derailment of northbound Canadian National (CN) freight train M33371 in Tamaroa, Illinois, and is consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued four safety recommendations, one of which is addressed to the American Railway Engineering and Maintenance-of-Way Association (AREMA). Information supporting this recommendation 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 recommendation.

About 9:04 a.m. central standard time on February 9, 2003, northbound CN freight train M33371, traveling about 40 mph, derailed 22 of its 108 cars in Tamaroa, Illinois. Nineteen of the 22 derailed cars were tank cars that contained hazardous materials or hazardous material residues. One pressure tank car was punctured, and seven general service tanks were breached. About 850 residents were evacuated from the area within a 3-mile radius of the derailment, which included the entire village of Tamaroa. No one was injured during the derailment, although one contract employee was injured during cleanup activities. Damages to track, signals, and equipment, and clearing costs associated with the accident totaled about $1.9 million.[1]

[1] For more information, see National Transportation Safety Board, *Derailment of Canadian National Freight Train M33371 and Subsequent Release of Hazardous Materials in Tamaroa, Illinois, February 9, 2003*, Railroad Accident Report NTSB/RAR-05/01 (Washington, D.C.: NTSB, 2005).

The National Transportation Safety Board determined that the probable cause of this accident was CN's placement of bond wire welds on the head of the rail just outside the joint bars, where untempered martensite[2] associated with the welds led to fatigue cracking that, because of increased stresses associated with known soft ballast conditions, rapidly progressed to rail failure.

The investigation determined that the equipment, supplies, and guidance for the Cadweld® exothermic welding process that CN used at the site of the derailment was provided by ERICO Products, Inc. (ERICO). ERICO also provided the equipment used for making Cadweld bond wire welds at St. Johns, the site of a previous CN insulated joint plug rail failure that the Safety Board evaluated as part of this accident investigation.

Safety Board examination of eight bond wire welds from Tamaroa and three welds from St. Johns found heat-affected zones with structures consistent with untempered martensite. Analysis of a failed CN Cadweld weld performed for CN by a metallurgical testing laboratory also revealed a martensitic structure beneath the weld. The hardness of the heat-affected zones in demonstration welds that ERICO produced for the Safety Board also was found to be near the maximum hardness associated with untempered martensite, indicating that little or no tempering was accomplished during the production of the weld. A re-bonded weld on the St. Johns rail did show a reduction in hardness and therefore a tempered martensite structure, suggesting that only a second heating process will truly temper the steels at exothermic welds.

Some railroads use pin brazing an alternative method of making electrical connections, including bond wire connections, to rails. But research conducted by Stanley Railroad Products, Inc., on the effects of high-temperature pin brazing on steel identified martensite to a depth of 1.5 millimeters (.059 inch) at pin-brazed welds.

To reduce stresses in the weld areas, bond welds at the rail head must be placed above the joint bars. The AREMA *Communication and Signal Manual*, at Part 8.1.30, figure 1, properly illustrates a bond wire on a rail head directly above a joint bar. But the signal bond wires at the insulated joints at Tamaroa and St. Johns had been welded to the rail head and base,[3] respectively, outside the limits of the joint bars.

At Chapter 4, "Rail," Part 4, Section 4.1, "Application of Rail Bonds," the AREMA *Railroad Engineering Manual* states:

> The application of pin connected bonds or welded bonds to the outer side of the rail head, within the limits of the joint bars for standard bonding and outside the joint bars for special work where not practicable to apply them within the joint bar limits, is good practice.

[2] *Martensite* is a hard and brittle crystal structure that occurs as a result of very rapid cooling (quenching) of heated steel (at about 1000º C or 1832º F per minute). Subsequent reheating of the steel to about 400º C (752º F) and holding it at this temperature for a time (tempering) produces a strong and tough steel with lower hardness and brittleness.

[3] The welds that had previously failed at St. Johns had been made to the rail base outside the joint bars. When the failed rail plug was replaced, the signal wires were welded to the head of the replacement rail.

But, as can be seen in the Tamaroa accident, placing welds on the rail head at locations outside joint bars is never good practice. Untempered martensite at such locations may create fatigue cracking that can propagate especially rapidly if, as at Tamaroa, track conditions allow greater-than-normal rail flexing.

On May 10, 1999, and as requested, ERICO sent AREMA recommendations for proper exothermic bond wire welding for inclusion in the AREMA *Railroad Engineering Manual*. Two of ERICO's recommendations addressed placement of the welds. First, ERICO stated that exothermic bond wire welded connections should only be placed on the rail head within the confines or limits of the joint bars. Second, ERICO stated that exothermic bond wire welded connections required outside of the joint bars should be welded to the rail web at the neutral axis. However, the UP railroad has reported that cracking in the rail web has occurred at exothermic bond wire welds. Proper placement of bond wire welds is a complex issue, and further study is needed to develop guidance on the placement of bond wire welds. The Safety Board concluded that the AREMA *Railroad Engineering Manual* does not adequately address the proper placement of exothermic bond wire welds.

The National Transportation Safety Board therefore makes the following safety recommendation to the American Railway Engineering and Maintenance-of-Way Association:

> Modify your *Railroad Engineering Manual* and/or your *Communications and Signals Manual* to address the proper placement of exothermic bond wire welds and high-temperature pin-brazings and to include information that these welds and brazings create untempered martensite that could, under certain conditions, lead to fatigue cracking and rail failure. (R-05-04)

The Safety Board also issued safety recommendations to the Federal Railroad Administration and ERICO Products, Inc. In your response to the recommendation in this letter, please refer to R-05-04. If you need additional information, you may call (202) 314-6177.

Chairman ENGLEMAN CONNERS, Vice Chairman ROSENKER, and Members CARMODY, HEALING, and HERSMAN concurred in this recommendation.

Original Signed

By: Ellen Engleman Conners
Chairman