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LOG R-468B

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: February 20, 1985

Forwarded to:

Honorable John H. Riley
Administrator
Federal Railroad Administration
Washington, D.C. 20590

SAFETY RECOMMENDATION(S)

R-85-4 and -5

About 10:09 a.m. on November 12, 1983, Amtrak train No. 21 (The Eagle), with 162 persons aboard, derailed near Woodlawn, Texas, while traveling at 72 mph on the Missouri Pacific Railroad (MP). The train was traveling westbound on the single main track when it passed over a section of rail that a repair crew had just installed to replace a broken rail. The break had occurred at a field weld in a length of new, continuous-welded, 136-lb RE section, chrome-vanadium alloy, high-strength, vacuum-treated rail, which had been installed in the track about 1 month earlier. The temporary repair consisted of removing a length of the outer rail in a curve and replacing it with a 19-foot 6-inch length of rail bolted in place. The repair insert was a section of used, 136-lb RE section, standard-carbon rail. The repair crew used an oxyacetylene torch to cut both the new alloy rail and the used standard-carbon rail during the repair. The accident resulted in 4 passenger fatalities and 72 injuries. Damage was estimated to be more than $2,180,000. 1/

The Federal Railroad Administration (FRA) commissioned a task force to conduct an evaluation of the rail failure in this accident. Its report 2/ states in part that:

> The trend toward increased usage of alloy rail is likely to continue as the long-term economic benefits are more widely recognized. Therefore, it is essential for the industry to be able to classify alloy rail steels on the basis of fracture toughness and to have specific guidelines for the manufacture, handling, installation, and maintenance of those alloys which are more notch sensitive than plain carbon rail steel.

1/ For more detailed information, read Railroad Accident Report--"Derailment of Amtrak Train No. 21 (The Eagle) on the Missouri Pacific Railroad, Woodlawn, Texas, November 12, 1983" (NTSB/RAR-85/01).

2/ For more information, see "Task Force Report-Rail Failure Evaluation, May 1984," prepared by U.S. Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts.

Fracture toughness is a measure of inherent resistance to fracture initation, and notch sensitivity is the tendency for a fracture to continue to progress. The report also states that it was ". . . probable that the torch cutting operation left a defect in the rail end, and that this initial defect probably provided the origin for the sudden rail failure" and that the metallurgical examination of the Union Pacific Railroad testing facility ". . . did not reveal the rail to have any unusual metallurgical characteristics." The report further states that within the railroad industry ". . . no consensus exists on torch cutting practices or on the slow orders to be imposed when a freight or passenger train is traveling over torch-cut rail."

The report made the following recommendations:

- The torch-cutting of rail for temporary jointed repairs should not be a preferred practice.

- If a torch-cut rail end must for any reason be left in a jointed temporary repair, railroads which do so to alloy rail should slow-order such repairs to a speed not exceeding 10 mph.

Also, the report recommended the following long-term actions:

- An industry study should be undertaken to assess quality control procedures to make certain that the manufacturing processes are not introducing excessive residual stresses in the product. Particular attention should be paid to the study of roller-straightening practices.

- An industry study should be undertaken on the experimental measurement of the fracture toughness of recent formulations of alloy rail steel. Detailed information on fracture toughness and fracture susceptibility, for loading conditions characteristic of normal train operations, would provide a rational basis for the development of recommended procedures for alloy rail installation and maintenance.

- An industry survey should be conducted to ascertain current alloy rail handling, installation, maintenance, and welding practices and produce acceptable practice guidelines since alloy rail may be less tolerant to otherwise similar practices than plain carbon rail.

The Association of American Railroads (AAR) and its engineering division, the American Railway Engineering Association (AREA), have begun tests and studies directed to the fulfillment of the long-term actions recommended by the task force and have indicated that a concerted industry effort will be necessary to achieve those goals.

The MP, as well as other railroads, have purchased and installed chrome-vanadium alloy rail and other high-strength alloy rail for the purpose of reducing the rate of rail replacement in locations of severe rail wear, such as in curves and track switch stock rails. The task force report on the rail failure in this accident has also indicated that the use of alloy rail, while currently very limited, will increase significantly because of the economic benefits of its wearability. The Safety Board does not question the appropriateness of industry seeking such economic benefit. However, the Board is concerned that indifference to proper methods of rail installation and maintenance which can result in safety hazards in any rail presents acute hazards when using certain high-strength alloy rails, such as chrome-vanadium alloy rail. The Safety Board's concern led to the issuance, during the investigation of this accident, of Safety Recommendation R-84-20 on April 20, 1984, to the AREA, the AAR and its membership, and the American Short Line Railroad Association, which states:

> Review and revise, where necessary, procedures for the installation and maintenance of high-strength alloy rails, especially high-strength chrome-vanadium alloy rails, to minimize the possibility of externally induced stress factors in such rails and to implement more stringent internal defect testing programs.

The majority of railroads that have responded to Safety Recommendation R-84-20 have rules and procedures in effect which specifically ban the use of a torch to cut rail except in an emergency situation. All of the railroads that have responded indicate that they have rules and procedures in effect which stipulate that rail cutting with a saw or rail chisel is the preferred method. Although the responses to Safety Recommendation R-84-20 do not comprehensively state the complete policies of all railroads regarding torch-cutting practices, the Safety Board believes they do indicate a consensus that cutting any rail with a torch is an unacceptable practice. Further, the Safety Board notes that although the FRA minimum track safety standards do not address the subject of torch cutting of rail at present, they do prohibit torch-induced bolt holes.

The Safety Board believes that the thermal cracks found in the chrome-vanadium alloy rail were precipitated by the use of the torch to cut the rail. Metallographic examination of the subject rail did not reveal any other internal defects that could have served as the origin of the rail fracture. Torch-cutting of rail often may introduce flaws at or near the torch-cut surface. The inherently uneven surface of a torch-cut rail has numerous surface discontinuities. These surface discontinuities, in a rail subject to the imposition of dynamic loads from wheels passing over the rail, serve as stress raisers. Stresses most often will occur in their highest intensities at such surface discontinuities. Further, there is a natural propensity for the heat-affected layer of metal adjacent to a torch-cut surface to form thermal cracks upon the cooling of the metal. These thermal cracks probably initiated the severe fracturing of the subject rail as Amtrak train No. 21 passed over it, 45 minutes to 1 hour after the torch cuts were made in the chrome-vanadium alloy rail.

The severity of the fracturing of the chrome-vanadium alloy rail was noted to be unique. The Safety Board believes that the severity of the fracturing may have been due to the very low fracture toughness of the rail. The low values established in the test specimens of the involved rail, in the tensile and impact resistance tests, are indicative of material possessing a low fracture toughness. Such material generally will have a greater tendency to fracture in a brittle manner. Stated in fracture mechanics terms, for a given flaw size, a material with lower elongation and impact resistance values can withstand less stress before failure. The hydrogen content analysis of the rail documented low levels of residual hydrogen, and the chemical analyses of the rail revealed no other anomalies which would account for the low elongation and impact resistance levels. In view of the absence of any specific agent responsible for the low test values, it appears likely that the displayed brittleness of the failed rail may be a characteristic typical of that category of alloy rail and that increased use of this type of rail may be expected to be accompanied by an increased incidence of similar failures.

Rail failure in a track curve or at a track switch often will result in more severe consequences than a rail failure that occurs on a straight (tangent) track. In the case of a track curve, the severe consequences are increased by the centrifugal or outward forces acting upon the equipment negotiating the track curve. In the case of a track switch or other special trackwork, the severe consequences are increased by the extra trackwork appurtenances within the track gage which the equipment must negotiate. In either event, the likely result is a more pronounced dispersal of equipment in the derailment. Moreover, the greater the extent of rail fracturing at such a location, with a concurrent greater loss of fixed guideway, the greater will be the potential for yet more pronounced dispersal of equipment in the derailment. These factors were present in the accident at Woodlawn and caused an uncommonly severe and lengthy loss of the fixed guideway, allowing the last three cars of the train to overturn. The overturning of the last three cars and the tilting of a car contributed significantly to the severity of injuries sustained by the persons onboard the train. The Safety Board believes that substantive research into this potential problem of catastrophic rail failure is necessary in view of the increased expected use of alloy rail in the industry. While chrome-vanadium alloy rail has been in service in foreign railroad systems for a longer period of time than in United States railroad systems, the knowledge concerning the characteristics of such rail acquired abroad is not totally and directly applicable to the United States railroad system because of differences in operational demands, including heavier axle loads in United States operations as well as differences in maintenance procedures. The Safety Board encourages the FRA to undertake the necessary research and provide the coordination necessary to insure that the task force recommendations are implemented.

Therefore, the National Transportation Safety Board recommends that the Federal Railroad Administration:

> Require that a maximum allowable operating speed not exceeding 10 mph be imposed on any railroad track having a torch-cut rail end in a bolted track joint. (Class II, Priority Action) (R-85-4)
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> In coordination with the Association of American Railroads and its membership, the American Railway Engineering Association, and the American Short Line Railroad Association, develop a plan to implement the long-term recommendations made in the Transportation Systems Center Task Force Report-Rail Failure Evaluation, vis:
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> - An industry study should be undertaken to assess quality control procedures to make certain that the manufacturing processes are not introducing excessive residual stresses in the product. Particular attention should be paid to the study of roller-straightening practices.
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> - An industry study should be undertaken on the experimental measurement of the fracture toughness of recent formulations of alloy rail steel. Detailed information on fracture toughness and fracture susceptibility, for loading conditions characteristic of normal train operations, would provide a rational basis for the development of recommended procedures for alloy rail installation and maintenance.

- o An industry survey should be conducted to ascertain current alloy rail handling, installation, maintenance, and welding practices and produce acceptable practice guidelines since alloy rail may be less tolerant to otherwise similar practices than plain carbon rail.

(Class II, Priority Action) (R-85-5)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY, Member, concurred in these recommendations.

By: Jim Burnett
Chairman