NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C. 20594

Safety Recommendation

Date: March 8, 1995

In Reply Refer To: R-95-2

Mr. Edwin L. Harper
President & CEO
Association of American Railroads
American Railroads Building
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Washington, D.C. 20001

On January 13, 1994, a northbound Ringling Bros. and Barnum & Bailey Circus (RBB&BC) train derailed about 9:08 a.m., eastern standard time, while passing through Lakeland, Florida, on CSX Transportation railroad en route to Orlando, Florida. A witness observed the train go by and saw two pieces of a wheel fly off a passenger car and land in nearby woods. The train continued 2.7 miles, across five grade crossings, with the broken wheel. When it reached the Park Spur turnout, 15 other passenger cars and 3 freight cars derailed. Of the 16 derailed passenger cars, 5 turned on their sides; the rest remained upright. Two circus employees were killed, and 15 received minor injuries.[1]

The postaccident investigation found that the wheel broke from the fatigue failure of a thermally damaged wheel due to fatigue cracking initiated at a stress raiser associated with a stamped character on the wheel rim.

The L-4 wheel on car 89 had broken into three pieces; one piece had remained attached to the axle. After the derailment, the two broken-off pieces from the wheel were recovered and taken along with the hub part of the wheel set to the local CSXT car shop for a preliminary

[1]For more information, read Railroad Accident Report--*Derailment of the Ringling Bros. and Barnum & Bailey Circus Blue Train Near Lakeland, Florida, on January 13, 1994* (NTSB/RAR-95/01).

inspection. The broken wheel and the mate wheel showed no signs of discoloration[2] on the wheel plates or on the tread. During initial examination, investigators noted the presence of what appeared to be "oyster shell" markings[3] on the fracture surface of the wheel where the wheel had broken below the deeply stamped *4* of the serial number on the back (inside) of the rim, along the vertical straight line of the number. The oyster-shell pattern is typical of a progressive failure from a fatigue crack.

The back face of the rim of the broken wheel was stamped, indicating that the wheel had been manufactured in September 1972 by the Standard Steel Division, serial number 4617, and was a controlled-cooled passenger-car straight-plate class B wheel that was 36 inches in diameter. The mate wheel was identical except that its serial number was 4611. According to the AAR *Manual of Standards and Recommended Practices*, Section A, Part III, "Passenger Car Requirements," class B wheels are designed for passenger cars in "high speed service with severe braking conditions and heavier wheel loads." The Vice-President of Quality and Technology for Standard Steel said that both the accident and mate wheels were from the same serial set, which was part of an original order of "probably 100 or 150 wheels for the Southern Railway." He further stated that he believed that the two wheels had stayed together since being first mounted on the axle and had never been removed from the axle.

The railroads have long understood the criticality of identifying overheated thermally damaged wheels. However, it is still practically impossible to detect a thermally damaged wheel outside a laboratory. The cracked and thermally damaged wheel was not detected before failure despite the fact that the RBB&BC train was inspected at Tampa by CSXT and RBB&BC personnel, passed a defect detector 18 miles from the derailment point, passed an observant maintenance-of-way gang that paused to inspect the train as it passed by, and was stopped and inspected by the train crew 10 miles from the point of derailment. The Safety Board concludes that thermal damage and cracking in the wheel could not be detected by routine railroad field inspection currently in practice.

Even in a laboratory, the only reliable methods of determining a thermally damaged wheel are destructive. One method is to radially cut the wheel. Such a cut in a thermally damaged wheel will generate a crack that will quickly propagate into the hub. Another method is an evaluation of the microstructure and hardness of a section cut from the wheel rim. The Safety Board metallurgical postaccident examination of the accident wheel showed that detection of small fatigue cracks in the wheel rim can be hindered because of their location and the amount of corrosion filling the cracks.

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[2]According to the U.S Department of Transportation *Handbook of Descriptive Technical Terms*, dated February 1983, overheating is defined, under "Hotspot," as "Subjected to excessive temperature usually evidenced by change in color and appearance of part."

[3]The markings are also known as fatigue, clamshell, beach, and crack-arrest markings. The markings are macroscopic growth lines or bands attributed to either changes in cyclic stress or periods of crack arrest followed by corrosion.

AAR research indicates that the stresses in thermally damaged railroad wheels are greatest on the back face of the wheel rim. Stamping the back of the wheel rim, as had been done to the RBB&BC accident wheel, provides a stress concentration point for a crack to start. Consequently, in 1978 the AAR prohibited the manufacture of rim-stamped railroad wheels on interchange freight cars. According to the AAR, few if any rim-stamped wheels are still in use on interchange freight cars, due to the relatively high attrition rate of freight-car wheels. However, some locomotives, transit cars, and private passenger cars still have wheels with stamped rims. Generally the wheels on these types of railroad vehicles are not as subject to thermal damage in normal operation as freight-car wheels are. Also, these types of railroad vehicles are not regularly interchanged as freight cars are.

Straight-plate wheels, which the RBB&BC train had, are more subject to thermal damage resulting in residual tensile stresses in the rim than curved-plate wheels. The curved-plate wheel acts much like a thermal expansion joint, which allows for elastic bending during overheating and consequently is less prone to formation of residual tensile stresses in the rim. As of January 1, 1994, the AAR prohibited freight-car wheel replacement with straight-plate wheels; all wheels on freight cars must be replaced with appropriate curved-plate wheels. About 90 percent of the 12 million wheels on the interchange freight-car fleet in this country are curved-plate wheels.

Most wheels on locomotives and passenger cars are still straight plate because they are changed infrequently. Locomotive and passenger-car wheel failure resulting from thermal damage to treads and rims is rare because these wheels are inspected more frequently than those on freight cars and because locomotives and passenger cars have better brake control valves. On many passenger and commuter cars, the use of disk rather than tread brakes has eliminated the possibility of overheating the tread and wheel rim, precluding thermal failure on these wheels.

The straight-plate B36 wheel, the type involved in this accident, was designed to be used on passenger trains, which are relatively short,[4] have passenger-brake valves, and receive frequent attention. These considerations greatly reduce the possibility of overheating a wheel. The RBB&BC train however was a mix of passenger and freight cars. It was much longer than a normal passenger train and did not have passenger-brake valves.

In summary, tread braking is a significant source of wheel overheating and thermal damage; straight-plate wheels are vulnerable to thermal damage, and rim stamping provides a stress concentration for crack initiation. Wheels that are particularly susceptible to thermal damage and subsequent fatigue failure are relatively few but have the potential to injure and kill passengers beyond their numbers since most of the problem wheels that are left are on private passenger cars.

Although initially masked by corrosion, visual examination of the mate wheel after the corrosion product was removed easily revealed a small fatigue crack that was estimated to be

[4]Shorter trains and their shorter brake pipes preclude many stuck brake problems from localized pressure conditions which are found more frequently in longer trains like freight trains.

about half the size of that on the numeral 4. The Safety Board believes that periodic close visual inspections with a low-power hand lens after cleaning the area are capable of detecting fatigue cracking in the stamping area long before the fatigue crack propagates to critical size. Such inspections may be enhanced by other nondestructive testing methods, such as magnetic particle inspections. To help ensure the integrity of these rim-stamped wheels, the Safety Board believes that operators should periodically inspect these wheels in the stamped areas for cracks and remove from service those wheels found to contain cracks.

The Safety Board is concerned about straight-plate rim-stamped tread-braked wheels that may remain in service for an extended period of time before requiring change out. Because of the extremely diverse conditions and environments in which private passenger cars operate, the Safety Board cannot assess the long term safety risk of such cars and their wheels. However, the Safety Board believes that all private railroad car organizations and private car owners should conduct a periodic inspection of their tread-braked rim-stamped straight-plate wheels to find any cracks emanating from the rim stamping and to remove the affected wheels. The Safety Board believes that the Federal Railroad Administration should prohibit future wheel replacement with rim-stamped straight-plate wheels on tread-braked cars. The Safety Board also believes that the AAR should prohibit the interchange of any tread-braked railroad car with rim-stamped straight-plate wheels until adequate inspection protection procedures are developed.

Therefore, the National Transportation Safety Board recommends that the Association of American Railroads:

> Develop and implement safe operating parameters that consider effective interchange inspection procedures and operating speeds for tread-braked passenger cars with rim-stamped straight-plate wheels. Until such a procedure is developed, prohibit the interchange of any tread-braked passenger railroad car equipped with rim-stamped straight-plate wheels. (Class II, Priority Action) (R-95-2)

Also, the Safety Board issued Safety Recommendations R-95-1 to the Federal Railroad Administration; R-95-3 to the National Railroad Passenger Train Corporation; R-95-4 and -5 to the American Short Line Railroad Association, the National Railway Historical Society, the American Association of Private Railroad Car Owners, Inc., the Association of Railway Museums, the Tourist Railway Association, Inc., and the National Passenger Car Alliance; R-95-6 and -7 to the Ringling Bros. and Barnum & Bailey Circus; and R-95-8 to CSX Transportation.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendation in this letter. Please refer to Safety

Recommendation R-95-2 in your reply. If you need additional information, you may call (202) 382-6840.

Chairman HALL, Vice Chairman FRANCIS, and Member HAMMERSCHMIDT concurred in this recommendation.

By: Jim Hall
Chairman