TECHNOLOGY DIGEST

Timely Technology Transfer

Testing a 76-Degree Crossing Under Heavy Axle Load Traffic

by Duane E. Otter and
Joseph LoPresti

TD 95-014

Summary

A 76-degree solid manganese crossing diamond was tested at the Facility for Accelerated Service Testing (FAST), Transportation Technology Center, Pueblo, Colorado. It withstood a total of 15.9 million gross tons (MGT) of heavy axle load (HAL) traffic before being removed from track due to cracks in one of the castings.

As a comparison , an 89-degree reversible manganese insert crossing previously tested at FAST (TD 93-005) only survived 1.9 MGT. The following reasons are given for the longer life of the 76-degree crossing:

- Harder running surface due to explosion hardening of castings
- Smoother running surface without wing-to-casting transitions
- Lower crossing angle resulting in smaller effective gap and lower impact forces

Maintenance performed during the test included extensive weld repair of a cracked casting after 10.8 MGT, build-up of batter at flangeway gaps, light grinding of running surfaces, tamping, and retightening of bolts.

Instrumented wheel sets were used to measure impacts in the crossing due to 100-ton (263,000 lb) cars and HAL (315,000 lb) cars at various speeds. The impact forces increased with increasing speed. The HAL car produced impacts that were about equal to those for a 5 to 10 mph higher speed with the 100-ton car. Average impacts were more than 2.5 times the static wheel load at 40 mph for both cars.

Suggested Distribution:
Operating/Engineering Dept.
- ☐ Maintenance of Way
- ☐ Maintenance Planning
- ☐ Planning & Analysis
- ☐ Track Maintenance

Association of American Railroads
Research and Test Department

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INTRODUCTION AND CONCLUSIONS

A 76-degree solid manganese crossing survived 15.9 million gross tons (MGT) of 315,000-pound heavy axle load (HAL) train traffic at the Facility for Accelerated Service Testing (FAST), Transportation Technology Center, Pueblo, Colorado (Exhibit 1). After 10.8 MGT of traffic, the crossing was removed from track to repair a crack in one of the castings. After the repair, the crossing was reinstalled and withstood an additional 5.1 MGT of HAL traffic. It was removed again due to additional cracks in the same casting. The new cracks were not in the repair welds or the associated heat affected zones.

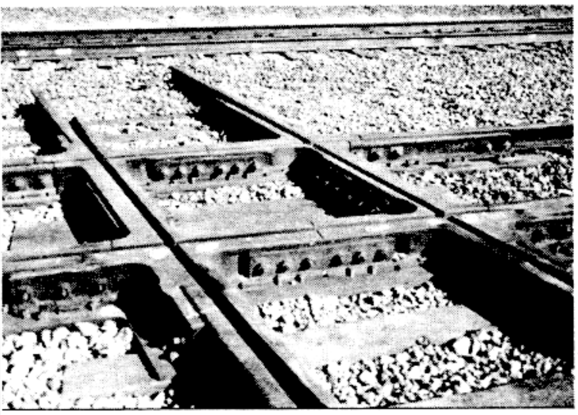

Exhibit 1. 76-Degree Solid Managanese Crossing

The FAST train operated in both directions over the mainline route of this crossing. The train typically ran 40 mph, with four 4-axle locomotives pulling about 60 cars. During the first 10.8 MGT of service, the ballast beneath the crossing was hand tamped every 1 to 3 MGT. The ballast contained a high percentage of slag, which appeared to deteriorate rapidly beneath the crossing. When the crossing was reinstalled, after the casting repair, granite ballast was used to minimize track surface problems.

Aside from the out-of-track repair of the cracked casting, the crossing also required in-track maintenance. The gage corners of the running surface were ground lightly every 2-3 MGT to remove metal flow and maintain flangeway clearance. No build-up welding was performed during the first 10.8 MGT, although the batter was about 1/4 inch at each of the flangeway gaps. The battered ends were built up in conjunction with the casting repair. Other portions of the running surface performed well, with no corrugations or batter after 15.9 MGT of HAL traffic. During this period, eight of the torque-stud bolts came loose and were retightened using a conventional track wrench.

This crossing lasted much longer than the 89-degree reversible manganese insert crossing, which only survived 1.9 MGT at FAST (TD 93-005). Reasons may include a harder running surface due to explosion hardening of the castings, lower impact forces due to a lower crossing angle, and a smoother running surface without the many wing rail-to-casting transitions of the reversible insert crossing.

FORCE MEASUREMENTS

Exhibit 2 summarizes the impact force data as measured using instrumented wheel sets. The average impacts under the HAL car are significantly higher than those under the 100-ton car. The impact forces increase with speed through 40 mph. The nonlinear increase may be due to yielding of the casting material. The impact forces produced by a HAL car are roughly equal to those produced by a conventional car at 5 to 10 mph higher speed. At 40 mph, the average impacts are more than 2.5 times the static wheel load for both cars.

Each point on Exhibit 2 represents the average of 32 measured impacts. At zero speed, the static wheel loads are plotted. The maximum impacts measured at 40 mph were 157 kips for the HAL car and 159 kips for the 100-ton car. This data complements measurements reported earlier for a 62-degree crossing. The forces are somewhat higher under the 76-degree crossing, most likely due to the higher crossing angle, which results in a larger effective gap at the flangeways (TD 94-018).

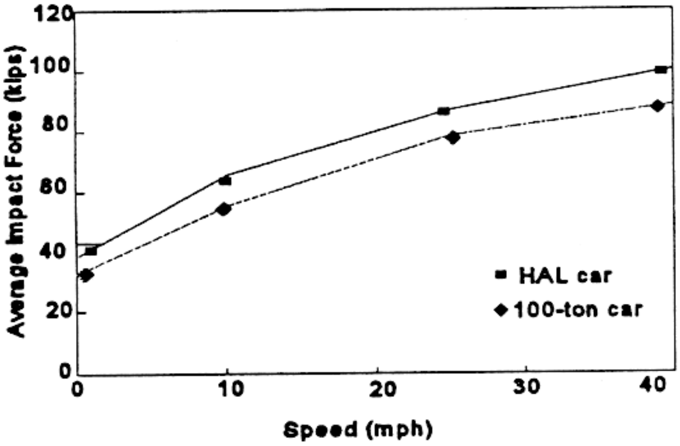

Exhibit 2. Average Impact Forces

These force measurements were made after 10.9 MGT of traffic passed over the crossing. The corners at the flangeway gaps had just been built up, and batter was minimal. Data was collected at a rate of 512 samples per second and filtered at 200 Hz.

WELD REPAIRS TO CASTING

One of the four castings was cracked extensively enough to warrant removal of the crossing for repairs after 10.8 MGT. The crack extended across the full width of the base of the section (Exhibit 3) and up into the vertical walls of the casting. The crack was visible in the bottom of the flangeways.

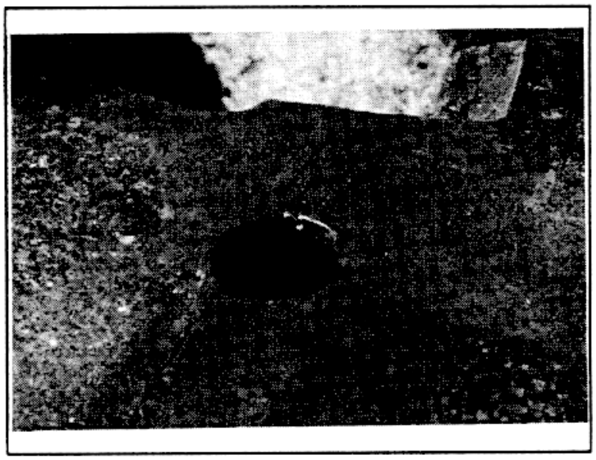

Exhibit 3. Crack in Casting of 76-Degree Crossing

Welders from Conrail and Sante Fe volunteered to supervise and assist in the repair. The portion of the crack that was readily accessible from the bottom of the casting was air-arced out, then ground into a smooth v-shape. It was decided it would not be cost effective to try to repair the cracks in the interior vertical walls of the casting.

Any large gaps caused by metal removal were backed up with 14-percent manganese applicator bar, as shown in Exhibit 4. Approximately one third of the "v" was welded with 3/16-inch Matweld 900 electrode. The repair was completed with 5/64-inch Frogbuild 570 wire, and the area was ground to match the rest of the casting.

There was no preheating or post heating of the casting. The temperature of the base material was kept below 400-degrees Fahrenheit during the repair. No weaving was used, and the maximum bead length was about 7 inches. The maximum bead width was about 1/2 inch. Despite these precautions,

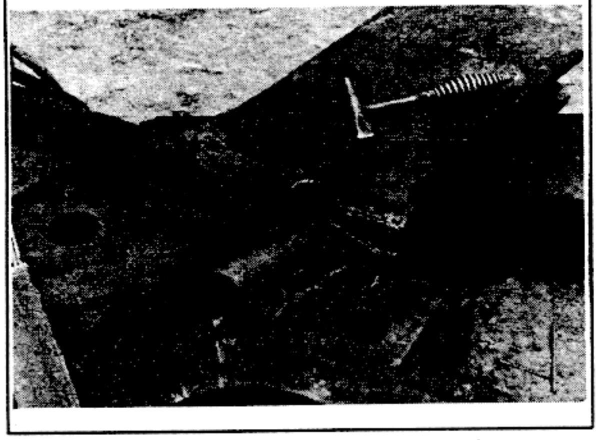

Exhibit 4. Cracked Casting During Weld Repair

small cracks developed in the parent material adjacent to the welds just after welding. The new cracks were removed and repaired where possible.

The corners of the castings at all four flangeway intersections were also repaired. Average batter was about 1/4 inch, with some metal flow and small cracks evident. All cracks and work-hardened material were removed with an air arc and/or a hand grinder. The first layer of welding was done with 3/16-inch Matweld 900 electrode in the areas where more than 3/4 inch of build up was required. The build up was completed with 5/64-inch Frogbuild 570 wire and ground to the proper height and shape.

DESIGN AND INSTALLATION

The 76-degree crossing was donated by Conrail and manufactured by Pettibone-Ohio Corporation, with three-shot explosion hardened solid manganese castings on an integral base. The average hardness of the castings was 340 Brinell. The leg and guard rails were Bethlehem 132 RE fully heat-treated rail. The steel work closely follows AREA plans Nos. 771-80 and 700F-80. The crossing angle is 76 degrees, 19 minutes. The bolts were Camcar Camrail high strength with torque studs. The crossing had not been in track before testing began at FAST.

The crossing was installed on the manufacturer's plates with cut spikes and oriented for FAST train operations over the route designed for heavier traffic. The branch line route was not connected to any other track. Bolted joints connected the crossing to the adjacent 132 RE rail. The rail surrounding the crossing was continuously welded. The ballast was a combination of granite and slag, with 12- to 15-inch shoulders, 2:1 slopes, and cribs full to the top of the ties.

ACKNOWLEDGEMENT

The authors acknowledge the assistance of both Conrail and Santa Fe personnel during the conduct of this test. Walt Heide, Conrail's director of standards and track analysis, was instrumental in donating the crossing and providing support for the casting repair. John Baker, Santa Fe's manager of track standards, also provided support for the repair. Welding supervisors Stan Markis and Daryl Rieck from Conrail; and welding supervisor John Mayhill, welders Karl Minck and Francis Story from Santa Fe worked with AAR track welders to perform the repair. Track-Weld Industries donated the welding consumables used in the repair.

Note: Contact Duane Otter at (719) 584-0594 with questions or comments about this document.