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Part 1: Heavy Axle Load Revenue Service Mega Site Testing 2005–2012

SUMMARY

Since 2005, the Federal Railroad Administration and the Association of American Railroads have jointly funded a heavy axle load (HAL) revenue service testing program with several objectives. One objective is to determine the effects of HAL traffic on track infrastructure by supplementing test activities performed at the Facility for Accelerated Service Testing (FAST) with a wider range of track, operation, and climatic conditions. The second objective is to identify issues that could negatively affect HAL operations and find solutions to address those issues. The third objective is to test and monitor new and alternative track designs and materials, as well as improve track maintenance procedures intended to mitigate the adverse effects of HAL traffic on track degradation.

Two revenue service mega sites (see Figure 1) were established for this research: one in the East near Bluefield, WV, and the other in the West near Ogallala, NE. In comparison, the eastern mega site typically has sharp curves (up to 12 degrees) and steep grades (up to 1.4 percent), wood ties, open deck steel bridges, 20 to 40 mph operating speeds, and 55 megaton (MGT) per year tonnage. The western mega site typically has shallow curves (1 to 2 degrees), concrete ties, ballast deck bridges, 40 to 60 mph operating speeds, and tonnage up to 250 MGT per year.

From 2005 through 2012, Transportation Technology Center, Inc. (TTCI), with help from host railroads, conducted a number of experiments. Some were designed to address safety items, such as the derailment potential related to broken rails, weld defects, and large wheel-rail forces due to adverse track geometry. Experiments were also designed to examine the effects of HAL on track component degradation, as well as the effectiveness of new and alternative materials, designs, and techniques developed to minimize negative HAL effects.

Part 1 (of two companion articles) gives a summary of experiments in the areas of rail, weld, rail joint, and rail neutral temperature.

Figure 1: Eastern (top) and Western (bottom) Mega Sites

PREMIUM RAILS

Ten premium rail types from six manufacturers were installed at both mega sites in 2005. The eastern mega site has four test curves from 6.8 to 12 degrees, whereas the western mega site has three test curves of 1 and 2 degrees. Most test rails had a Brinell hardness number (BHN) just below 400 as installed, but were all work-hardened from traffic to above 400 BHN.

To date, 415 MGT has accumulated in the test curves at the eastern mega site, and 1,800 MGT has accumulated in the test curves at the western mega site. All test rails have shown excellent wear performance (i.e., natural wear from traffic was not projected as the main reason for future rail replacement, even for the sharp curves). The average natural wear rate of high rail was 0.02, 0.05, and 0.1 inch per 100 MGT for the 2-, 6.8- and 10.5-degree test curves, respectively. In addition, no internal flaws were identified for any of the test rails.

Rolling contact fatigue (RCF) was found to be the main issue for the premium rail, especially on the low rail running surface. Occurrence of RCF also depended on track curvature. At the eastern mega site, with top of rail (TOR) friction control implemented from the beginning of the experiment, RCF occurred after 250 MGT for the 10.5-degree curves, but was not observed for the 6.8-degree curves until after 350 MGT.

At the western mega site, without TOR friction control, RCF occurred after 300 MGT for the 2-degree curves, but was not observed until after 1,000 MGT for the 1-degree curve.

PREVENT ROLLING CONTACT FATIGUE

Two maintenance strategies were found to be effective to address RCF: TOR friction control and preventive grinding. At the eastern mega site, gage face lubrication and TOR friction control were implemented in all premium rail test curves. With grinding not allowed for the sake of testing, it took 250 MGT for the low rails of 10.5-degree curves to develop RCF (a corrective grinding was done at 275 MGT), and it took 350 MGT for the 6.8-degree curves to develop RCF (a corrective grinding was done at 365 MGT).

Monitoring was also conducted for standard rails in two groups of curves at the eastern mega site. One group implemented both gage face lubrication and TOR friction control, whereas the other group implemented only gage face lubrication. Measurements showed that implementation of TOR friction control reduced vertical railhead wear by approximately 30 percent. In addition, TOR friction control reduced loss of rail metal from grinding operations, suggesting that TOR friction control reduced the occurrence of RCF.

At the western mega site, corrective grinding was used to remove RCF (from 690 MGT following a corrective grinding); however, one 2-degree curve implemented TOR friction control, whereas the other 2-degree curve implemented preventive grinding at an interval of 70 to 110 MGT. Subsequent monitoring showed that as a result of TOR friction control, RCF did not appear until an additional 960 MGT accumulated, compared to 300 MGT without TOR friction control. Preventive grinding was also found to be more effective compared with corrective grinding, reducing by 3.5 times the amount of metal removed due to grinding when rails were ground on a 100 MGT interval.

WIDE-GAP WELDS

Thermite wide-gap welds (WGW) were developed to join two rails with a nominal gap of 2.75 inches. Because of their extra width, WGWs can be used to directly replace most field weld defects and some rail defects without plug rails. This could lead to several major benefits, including fewer welds being performed in the field (a plug rail uses two welds) and less track time for replacing such defects, thus improving train operating safety and reducing track maintenance costs.

In 2005 and 2006, 32 WGWs were installed at the eastern mega site. A 7-year testing effort has shown that WGWs are a viable rail joining practice for HAL operating environments. Even without the benefits of preventive grinding (for testing purposes), these welds had a minimum fatigue life of 265 MGT, with the average life projected to be 490 MGT. Spalling and plastic flow were the early signs of surface degradation. When not ground, these surface issues grew into shelling problems that required attention. Life expectancy of WGWs is expected to increase if preventive grinding is implemented to remove minor spalling and plastic flow in a timely fashion.

INSULATED RAIL JOINTS

Monitoring of improved insulated joint (IJ) designs has been one of the major experiments at the western mega site. The early experiment (2005 to 2009) measured 48-inch (8-hole) bonded bars with the end post of the joint supported on the tie against 36-inch (6-hole) bonded bars with the end post of the joint suspended in the crib. Testing efforts showed that the suspended design failed at 330 MGT because of a broken bar (fatigue crack), whereas the supported IJ design had a minimum life of 1,000 MGT (fatigue crack was also the failure mode). Note: average service life of IJs before 2005 was 280 MGT.

In 2011, 28 improved design IJs were installed at the western mega site to monitor long-term performance of various designs, including IJs with ceramic end posts, hi-modulus bars, and fiberglass or improved epoxy, as well as centerline and tapered IJs. Testing and monitoring of their performance is currently in progress.

RAIL NEUTRAL TEMPERATURE

At the western mega site, a test curve was established in 2005 with two types of rail neutral temperature (RNT) devices installed to monitor changes in RNT as a result of traffic, seasonal changes, and track maintenance activities. This curve has also been used as a test bed for evaluating new technologies developed for measuring RNT.

Test results showed that 72 hours of traffic reduced RNT by approximately 10°F from the as-installed RNT, and its daily variation was measured to be approximately 5°F at this site. In addition, a broken rail and subsequent bolting, welding, and traffic caused large variations of RNT within 250 feet. Due to this rail break, an immediate drop of RNT from 115°F to 56°F was recorded at a measurement location

92 feet from the point of the break. The daily variation of RNT after bolting (installing temporary joint bars), but before welding, was more than 10 degrees.

RAIL ANCHOR (CONCRETE TIES)

In 2007, a test was conducted at three locations with IJs at the western mega site to evaluate the performance of rail anchors designed for concrete ties. The anchors are essentially regular rail anchors for wood ties, but have plastic covers that provide insulation between the rail and the concrete and help keep the anchor from damaging the concrete.

Test results showed that these anchors did not provide added benefits as far as reducing short- and long-term changes in RNT, nor did they prevent a large drop in RNT when the joint bars cracked at one of the test locations. In essence, the anchors installed on the concrete ties at IJ locations did not provide additional longitudinal resistance when no apparent longitudinal rail movement was observed. In addition, measurement of fastener toe load indicated little difference in the magnitude of toe load or its change over time between rail with and without anchors.

FUTURE ACTION

In 2013, several new experiments are being initiated to evaluate performance of new premium rails, railhead defect repair welds, optimized methods to control rail RCF, and advanced frog designs in revenue service operations.

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CONTACT

Luis Maal
On-Site Resident Engineer Program Manager
Federal Railroad Administration
Office of Research and Development
Office of Railroad Policy and Development
55500 DOT Road
Pueblo, CO 81001
(719) 584-0551
luis.maal@dot.gov

Gary Carr
Chief – Track Research Division
Federal Railroad Administration
Office of Research and Development
Office of Railroad Policy and Development
1200 New Jersey Ave., SE
Washington, DC 20590
(202) 493-6354
gary.carr@dot.gov

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