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TESTING OF WIDE-GAP WELDS AT EASTERN MEGA SITE

SUMMARY

In 2005, Transportation Technology Center, Inc. (TTCI) and Norfolk Southern Railway (NS) began a test of wide-gap welds (WGWs) at the eastern mega site near Bluefield, WV.

WGWs enable the repair of weld or railhead defects with a single weld instead of the typical rail plug-and-weld procedure that requires two welds. A defect limited to less than 2.75 inches in the longitudinal direction can be replaced with a single WGW.

Two types of WGWs were installed adjacent to a high strength rail test: 16 Orgo-Thermit welds in 2005 and 16 Railtech Boutet welds in 2006 (see Figure 1). The WGWs have accumulated 355 and 300 million gross tons (MGT) of traffic, respectively. The following are the main findings from this test:

WGW is a viable rail-joining practice for heavy axle load operating environments. Even without the benefits of regular preventative grinding, these welds have shown a minimum fatigue life of 265 MGT, with an estimated average life of 490 MGT. With preventative grinding to remove minor spalling and plastic flow, life expectancy under these conditions is expected to be longer.

WGWs exhibited running surface degradation consistent with that observed in standard gap thermite welds, but the degree of degradation was greater and occurred faster for WGWs compared with standard gap welds.

Two Railtech Boutet WGWs were removed because of internal porosity defects detected by ultrasonic inspection. The first defect was found upon installation, and the weld was replaced. The second defect was found after 209 MGT, and the weld was removed from the test.

Two Orgo-Thermit WGWs were removed. One weld experienced a fatigue fracture that initiated at flashing under the base. The fracture occurred shortly after the weld developed a shell on the gage corner. The second weld was removed when inspection revealed a similar gage corner shell.

This research was conducted by TTCI, in conjunction with NS, and it was funded by the Association of American Railroads and the Federal Railroad Administration.

Figure 1. WGWs—Railtech Boutet (left); Orgo-Thermit (right)

BACKGROUND

In 2005, TTCI and NS started a WGW test at the eastern mega site near Bluefield, WV. Welds from two manufacturers were installed 1 year apart. In October 2005, 16 Orgo-Thermit welds were installed in the spirals adjacent to premium rail test curves. The welds were staggered between low and high rail, and provision was made for later installation of additional welds. One year later, 16 Railtech Boutet welds were installed in the reserved locations.

WGWs are thermite welds that incorporate a wider gap (2.75 inches) between rail ends than standard thermite welds (1 inch). WGWs were developed as an alternative repair process to the conventional rail plug-and-weld procedure. The wider gaps enable the use of a single weld to repair railhead defects. Welds or rails with defects or transverse breaks limited in the longitudinal direction to less than 2.75 inches can be repaired by the use of a single WGW, reducing labor and out-of-service time for the track.

The eastern mega site averages 55 MGT of mixed traffic per year, of which approximately 50 percent is heavy axle load (HAL) coal trains. The weld test zone has 141 RE rail with cut spikes and wood ties.

OBJECTIVES

The primary objective of this test was to evaluate the performance of WGW's in revenue service HAL conditions. TTCI has conducted testing of WGWs at the Facility for Accelerated Service Testing in Pueblo, CO. Testing as part of the mega site program enables observation of service performance under a broader range of HAL conditions.

METHODS

TTCI conducted semiannual inspections and measurements of the welds throughout the test period. Inspections were conducted visually and ultrasonically, and weld longitudinal profile and surface hardness measurements were taken.

RESULTS

Measurements of weld profiles and hardness showed trends consistent with those observed for standard thermite welds. Figure 2 shows longitudinal running surface profiles for one WGW measured at different MGT levels. The softer heat-affected zones (HAZ) quickly battered under HAL, but the rate of batter slowed in comparison with the rate of batter for the adjacent zones. (Batter is metal deformation and flow at the running surface resulting from high wheel-rail forces.). By contrast, the center of the weld experienced a steady batter rate resulting from wheel impacts as they traversed the HAZ.

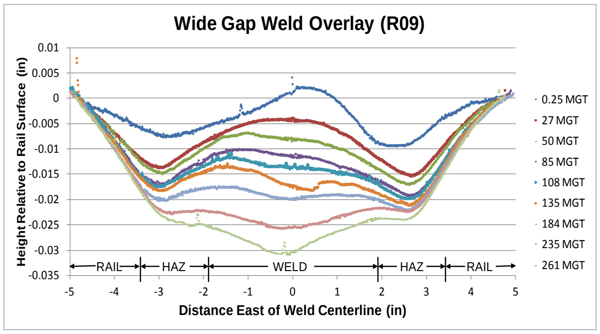

Figure 2. Weld Profile Degradation—Primary Direction of Loaded Traffic is Left to Right

During the course of the testing, four WGWs were removed or failed. Table 1 summarizes the removals and provides the tonnage accumulated.

Table 1. Summary of Weld Removals

Weld ID	Reason Removed	Defect	Date	MGT
WGW R4	Ultrasonic Indication	Gas Hole in Web	10/2006	0
WGW R12	Ultrasonic Indication	Gas Hole in Web	10/12/2010	209
WGW O6	Service Failure	Runout, Bottom Base	10/17/2010	265
WGW O3	Surface Condition	Shelling of Gage Corner	11/2011	321

Figure 3 shows the weld that was removed due to base fatigue that occurred approximately 2 months after it developed a shell on the running surface. Figure 4 shows the two welds with internal gas-hole defects after removal and cross-sectional examination.

Figure 3. WGW O6 with Shelling on Gage Corner and Fatigue Fracture from Base of Weld—Inset Shows Fracture Face—Fatigue Initiated at Runout at Base of Weld

Figure 4. Gas Holes in Railtech Welds R4 (left) and R12 (right)

In August 2005, approximately 14 thermite welds with standard 1-inch gaps were used to install the rail test at the eastern mega site. In 2007, two welds were removed for maintenance purposes when a timber bridge in the rail test zone was converted from open deck to ballasted deck. None of the remaining 12 welds experienced service failures. The standard gap welds experienced running surface degradation similar to the WGWs, but to a lesser degree. The welds developed metal flow at the HAZ and at the weld. One weld developed a shell at the gage corner. Similar to the WGWs, standard gap welds that received rail grinding had reduced running surface degradation.

TTCI performed a Weibull analysis based on the test results shown in Table 1 to estimate the time to failure, or expected life, for the welds under similar HAL revenue service operating conditions. On average, this analysis shows that 50 percent of the welds in the test will fail by 490 MGT, and almost all the welds will fail by

740 MGT. Based on the test at the eastern mega site, the minimum fatigue life of these welds is 265 MGT. However, with preventative grinding to remove minor spalling and plastic flow, life expectancy under these conditions is expected to be longer.

CONCLUSIONS

A 6-year field-testing effort has shown that WGW is a viable rail-joining practice for HAL operating environments. Even without the benefits of regular preventative grinding, these welds have had a minimum fatigue life of 265 MGT, with the average life estimated to be 490 MGT. With preventative grinding to remove minor spalling and plastic flow, life expectancy under these conditions is expected to be longer.

Spalling and plastic flow are the early signs of surface degradation issues. If not ground, these surface issues can grow into shelling problems that lead to service failures.

The profile and hardness monitoring of WGWs at the eastern mega site has concluded; however, semiannual visual inspections will continue, and any future failures will be noted and investigated, as needed, by NS Research and Test Department and TTCI.

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KEYWORDS

Wide-gap weld, thermite, revenue service