TECHNOLOGY DIGEST

Timely Technology Transfer

"THERMITE WELD PERFORMANCE UNDER HEAVY AXLE LOAD OPERATIONS AT FAST,"

by Greg Garcia and
Jon Hannafious

TD 95-020

Summary

Failure rates of standard thermite welds installed for both test and maintenance purposes at the Facility for Accelerated Service Testing (FAST), Transportation Technology Center (TTC), Pueblo, Colorado, have been reduced to 20 percent from 80 percent on the high rail and to 6 percent from 19 percent on the low rail after 75 MGT of heavy axle load testing.

After identifying the need to improve reliability and the life of thermite welds, a weld manufacturer and the Association of American Railroads took the following actions to reduce failure rates:

- Re-trained TTC welders
- Held discussions with the weld manufacturer regarding failure modes and tonnages
- Cooperatively installed test welds at TTC with an AAR member railroad
- Modified the standard mold design

Also, the maintenance weld currently used at FAST has been changed from a standard to a premium weld (370 Brinell Hardness), which demonstrates a higher resistance to shelling under HALs (the main failure mode of standard welds at FAST). Discussions with railroad personnel suggest that web cracking, the primary failure mode of premium welds at FAST, is an issue in revenue service that still needs to be addressed.

Current FAST thermite weld investigations include existing and prototype welds with varying weld chemistries, mold designs and installation procedures.

Suggested Distribution:
- ❑ R&D/Test Dept.
- ❑ Operating/Engineering Department
  - Maintenance of Way
  - Maintenance Planning
  - Track Maintenance

Association of American Railroads
Research and Test Department

September 1995

INTRODUCTION AND CONCLUSIONS

Observations of thermite weld tests conducted at the Facility for Accelerated Service Testing (FAST) at the Association of American Railroads (AAR), Transportation Technology Center (TTC) in Pueblo, Colorado, show that 39-ton axle loads adversely affect the performance of standard thermite welds. After identifying the need to improve reliability and life of thermite welds, actions taken by both the manufacturer and the AAR have brought a substantial reduction in failure rates.

RESULTS

Performance testing of track components and materials at FAST was conducted under a 33-ton axle load train from 1985 until 1988. From 1988 until 1995, testing was conducted with a 39-ton axle load train (39-ton or Heavy Axle Loads -HAL). HAL testing was conducted in two phases. Phase I was conducted from July, 1988 until June, 1990 to investigate the performance of standard track materials/components under HAL traffic. Phase II was conducted from December, 1990 until May, 1995 to investigate the performance of premium materials/components under HAL traffic.

During 100-ton car testing, 13 standard thermite welds were installed in the curves of the FAST High Tonnage Loop (HTL). Seven welds were installed on high rails and six on low rails. Of these welds, two failed on the high rail due to shelling of the weld material prior to 65 MGT.

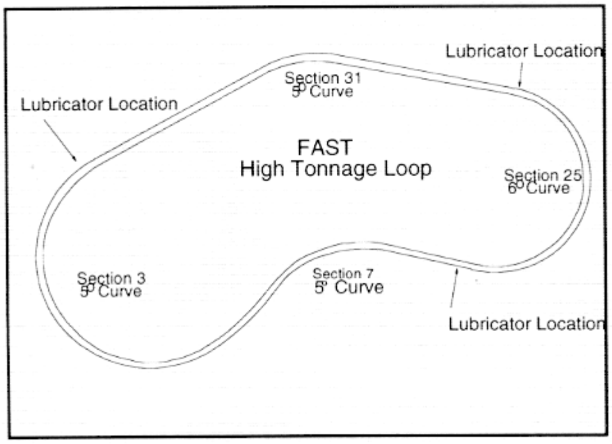

Exhibit 1. Map of HTL

HAL Phase I Tests

At the beginning of HAL Phase I, 36 standard thermite welds were installed in 5- and 6- degree curves on the HTL (Exhibit 2).Twenty welds were placed in the high rail and 16 welds in the low rail. Exhibit 2 lists the weld location by track sections, failure mode if any, and failure tonnage or tonnage when removed from track.

Exhibit 2. Thermite Welds in Test During HAL Phase I (High (H) and Low (L) Rail).

HTL Section	H/L	Failure Mode	MGT
03	H	Detail Fracture	81.7
03	H	Web Crack	41.2
03	H	Base Crack	36.3
03	H	Shelled	143.9
03	H	Shelled	36.3
03	H	Web Crack	45.2
07	H	Web Crack	36.2
25	H	Shelled	71.2
25	H	Shelled	71.2
25	H	Shelled	64.1
25	H	Shelled	29.2
25	H	Web Cracked	76.4
25	H	Shelled	50.1
25	H	Web Crack	22.4
25	H	Web Crack	56.4
25	H	Shelled	58.8
25	H	Shelled	58.8
25	H	None	143.9
25	H	Shelled	55.5
31	H	Detail Fracture	56.2
03	L	Detail Fracture	143.9
03	L	Shelled	143.9
03	L	None	143.9
03	L	VSH, Shelled	143.9

HTL Section	H/L	Failure Mode	MGT
03	L	Batter	48.8
03	L	Base Fatigue	84.4
03	L	Web Crack	80.4
25	L	None	143.9
25	L	Shelled	143.9
25	L	Web Crack	94.5
25	L	Detail Fracture	143.9
25	L	Battered	65.0
25	L	Web Crack	94.9
25	L	Shelled	143.9
25	L	None	143.9
31	L	Shelled	56.2

From Exhibit 2 the following observations can be made:

High Rail

- All but one thermite weld was removed from track due to failure. (The final weld was removed due to a rail change.)
- Sixteen of the 20 welds evaluated had failed prior to 75 MGT(80%).
- The primary modes of failure were from shelling and horizontal web cracks.
- The average life for all welds in Phase I testing on the high rail was approximately 62 MGT (143.9 maximum).

Low Rail

- Thirteen of 16 thermite welds were removed from track due to failure. (Three welds were removed due to a rail change.)
- Three of the 16 welds evaluated had failed prior to 75 MGT (19%).
- The primary modes of failure were from shelling and horizontal web cracks.
- The average MGT for all welds in Phase I testing on the low rail was approximately 114 MGT (143.9 maximum).

HAL Phase II Tests

Due to the high failure rate of thermite welds during Phase I testing, FAST engineers set out to ensure better weld quality for Phase II. AAR welders were re-trained by the weld manufacturer in thermite weld installation. Subsequently, they were sent to general weld training school at the Burlington Northern facility in Kansas City. Finally, an AAR member railroad was invited to install their railroad's standard weld at TTC, allowing AAR's welders to observe. Though there were subtle differences in processes between AAR, the manufacturer, and the railroad, all agreed on the best procedures.

Meanwhile, the weld manufacturer adopted a new mold design aimed at reducing failures from web cracking. The mold provides for a smoother finish in the web and thus fewer fatigue initiation sites. All welds provided by the manufacturer now have this design.

Finally, to investigate weld performance under HAL traffic, combinations of standard and premium chemistries and/or standard or modified mold designs were installed in a dedicated weld test section of the HTL. The installation was monitored closely by the manufacturer's representatives.

Seventy-one thermite welds were installed for Phase II testing. Thirty seven of these welds were premium, the results of which will not be included in this paper other than to make two points. First, a substantial number have developed web cracks. Second, discussions with revenue service personnel suggest this is an important issue in revenue service since the failures are occurring there also. The results for the premium welds will be presented at the FAST Open House in November, 1995.

The remaining 36 welds installed were standard (16 on the low rail and 20 on the high rail). Exhibit 3 identifies the weld location (Section 31), failure modes if any, and the accumulated tonnage prior to removal from track for either failure or rail change.

Exhibit 3. Thermite Welds in Test During HAL Phase II (High (H) and Low (L) Rail).

HTL Section	H/L	Failure Mode	MGT
31	H	Base Fatigue	23.1
31	H	Web Crack	49.7
31	H	Web Crack	49.7
31	H	Shelled	56.0
32	H	Still In Test	70.0
32	H	Still In Test	70.0
31	H	Still In Test	74.1
31	H	Still In Test	74.1
31	H	Still In Test	74.1
31	H	Still In Test	74.1
31	H	Rail Change	79.1
31	H	Shelled	79.1
31	H	Shelled	79.1
31	H	Shelled	79.1
32	H	Still In Test	101.5
31	H	Still In Test	101.5
31	H	Still In Test	101.5
32	H	Still In Test	101.5
31	H	Web Crack	113.2
31	H	Still In Test	153.2
31	L	Shelled	26.6
32	L	Still In Test	70.0
31	L	Still In Test	74.1
31	L	Still In Test	74.1
32	L	Still In Test	74.1
32	L	Still In Test	74.1
31	L	Rail Change	79.1
31	L	Rail Change	79.1
31	L	Rail Change	79.1
31	L	Rail Change	79.1
31	L	Rail Change	79.1
31	L	Shelled	79.1
31	L	Still In Test	101.5
30	L	Still In Test	101.5
32	L	Still In Test	102.3
31	L	Still In Test	153.2

From Exhibit 3 the following observations can be made:

High Rail

- Eight of 20 thermite welds have been removed from track due to failure. (One weld was removed due to a rail change.)
- Four of the 20 welds failed prior to 75 MGT (20%).
- The primary modes of failure were from shelling and horizontal web cracks.
- Eleven welds remain in test on the high rail.

Low Rail

- Two of 16 thermite welds have been removed from track due to failure. (Five welds were removed due to a rail change.)
- One of the 16 welds failed prior to 75 MGT (6%).
- The only mode of failure was shelling.
- Nine welds remain in test on the low rail.

Note: Contact Greg Garcia (719) 584-0660 or Jon Hannafious (719) 584-0682 with questions or comments about this document.

A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, WILL BE AVAILABLE AT A LATER DATE THROUGH THE AAR, PUBLICATION ORDER PROCESSING, 50 F STREET, NW, 5TH FLOOR, COG, WASHINGTON, DC 20001