TECHNOLOGY DIGEST

Timely Technology Transfer — 99-006

BENCHMARKING RESULTS OF NORTH AMERICAN RAIL-FLAW DETECTION TECHNOLOGIES

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Summary

Evaluations of six hi-rail ultrasonic rail-flaw detection systems have demonstrated performance capabilities within recommended guidelines of the American Railway Engineering and Maintenance of Way Association (AREMA). The capabilities of the detection systems were benchmarked over an evaluation track located at the Federal Railroad Administration's (FRA) Transportation Technology Center near Pueblo, Colorado. This Rail Defect Test Facility (RDTF) contains rail discontinuities found in North American track. A complete description of the RDTF can be found in a companion Technology Digest, "The Rail Defect Test Facility: A Tool for Evaluating Defect Detection Technologies."

The 49 defects known to be in the track were two 0.25-inch bolt-hole cracks, four defective welds of between 5 and 15 percent in size, 40 transverse defects (TDs) ranging from 3 to 80 percent in size, two horizontal split heads, and one vertical split head. Overall, 72 percent of all flaws in place were detected in the six benchmarking runs. Although reliability in detection varied somewhat by flaw type and size, generally the performance was within guidelines recommended by AREMA.

Benchmarking evaluations have been funded through a test program sponsored by the Association of American Railroads and the FRA. The rail-defect-detection contractors and member railroads provided detector cars and technical support during the evaluations. Future testing will be performed on the RDTF to evaluate improved inspection processes and new technologies introduced for rail-flaw detection.

Suggested Distribution:

- ❑ Maintenance of Way
- ❑ Planning & Analysis
- ❑ Track Maintenance
- ❑ Safety

Work performed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads
February 1999©

INTRODUCTION

Evaluations of various types of rail-flaw detection systems operating over known internal flaws in rails are being conducted at the Federal Railroad Administration's (FRA) Transportation Technology Center (TTC) on the Rail Defect Test Facility (RDTF). Internal rail defects occur as a consequence of the rail-manufacturing process as well as the accumulation of fatigue under repeated loading.

Detection of rail flaws before they progress to complete failure is important. Track-integrity problems such as broken rails, transverse defects (TDs), and vertical split heads comprise the third highest cause of train derailments. TTCI estimates for rail-flaw inspection and derailment costs related to rail flaws, are approximately $185 million annually. Increasing the reliability of detection through process improvements and technology enhancements may reduce inspection costs and derailments related to rail flaws by approximately 25 percent in each category for a savings of $66 million annually.

The RDTF is located on a gauntlet track and was constructed in 1997 in a cooperative effort undertaken by the Association of American Railroads (AAR) and the FRA. A description of the RDTF can be found in TD-99-002. The RDTF provides AAR member railroads, the FRA, and industry suppliers with a tool to assess detection technologies over known rail flaws in a controlled environment. Ongoing and future evaluations of new and emerging technologies are planned for the RDTF. Future evaluation results will be compared to these 1998 benchmarking tests.

RDTF BENCHMARKING RESULTS

Benchmarking evaluations of six different hi-rail ultrasonic inspection systems were performed between February and May 1998. The evaluations were performed by three North American rail-flaw contractors to provide a baseline characterization of current capabilities for detection of known flaws using rail located in the RDTF at TTC. The benchmarking evaluations have been performed in participation with member railroads, the FRA, rail-flaw-detection contractors, and technical staff from TTCI.

Forty-nine of 70 available in-track rail flaws were selected for benchmarking purposes. The rail flaws included TDs with sizes ranging from 3 to 73 percent of the cross-sectional railhead area, bolt-hole cracks, and defective welds, as well as horizontal and vertical split heads. The TDs consisted of those located under shells (seven) and those with no apparent surface anomalies present (33). Results of the six evaluations identify a hit (detected rail flaw) percentage for TDs under shells at approximately 62 percent and the hit percentage for those not under shells at 77 percent. It should be emphasized that the defects installed at the RDTF had been previously identified during revenue-service inspections by the member railroads and verified by TTCI prior to placement in the RDTF.

Exhibit 1 lists the rail flaws used to perform the benchmarking evaluations at TTC. The hits identified during the evaluations were subsequently hand-mapped for verification by railroad and TTCI personnel. The flaws not detected during the evaluations were identified and verified by all participants after the rail-flaw run. The results of the six benchmarking evaluations are given in Exhibit 2. Evaluation No. 1 (E1) through evaluation No. 6 (E6) correlate with the six cars tested.

The defects known to be in the track were two 0.25-inch bolt-hole cracks, four defective welds of between 5 and 15 percent in size, 40 transverse defects (TDs) ranging from 3 to 80 percent in size, two horizontal split heads, and one vertical split head. Overall, 72 percent of all known flaws in place were detected in the six benchmarking runs, with a breakdown by defect type as follows:

Flaw Type	Flaw Size Percent Head Area or inches (cm.)	Number of Flaws
Bolt Hole Crack	0.25 & 0.38 (0.64 & 0.97)	2
Defective Weld	5 to 15%	4
Horizontal Split Head	2x1 (5.1x2.5) & 3x2 (7.6x5.1)	2
Transverse Defect	3 to 10%	17
Transverse Defect	11 to 20%	9
Transverse Defect	21 to 40%	9
Transverse Defect	41 to 80%	5
Transverse Defect	81 to 100%	0
Vertical Split Head	120 (304.8)	1

Exhibit 1. Rail Flaws Used for Benchmarking Evaluations on the RDTF

Evaluation Identification	Actual Hits (49 Possible)	Flaw Hit Percentage
E1	32	65%
E2	36	73%
E3	34	69%
E4	36	73%
E5	38	78%
E6	37	76%

Exhibit 2. Benchmarking Results from Detection-System Evaluations on the RDTF

- The reliability of detecting bolt-hole cracks was 33 percent.
- The reliability of finding defective welds was 54 percent.
- The reliability of finding TDs was 75 percent, with a breakdown as follows:
  - — 66 percent of TDs 20 percent in size and smaller were detected.
  - — 96 percent of TDs 21 percent in size and larger were detected.
- The reliability of finding horizontal split heads was 92 percent.
- The reliability of finding the vertical split head was 100 percent.

The detection reliability of all cars for all evaluations by defect sizes is shown in Exhibit 3. Defect sizes of less than 30 percent are exhibited in 5-percent intervals. The detection percent (eg: for defects 11 percent to 15 percent in size was shown to be 60 percent) will be used to evaluate alternative technologies and improvements to existing technologies. In 1992 a "Recommended Minimum Performance Guideline for Rail Testing" was incorporated as Section 2.2 to the American Railway Engineering and Maintenance of Way Association (AREMA) Manual for Railway engineering. Exhibit 4 shows the AREMA recommended performance for mainline track with annual tonnage greater than 3 MGT. TTC benchmarking reliability is also shown, which has been recalculated to match the five groupings of the AREMA guidelines.

Exhibit 5 shows the AREMA recommended guidelines along with the reliability of detection determined from initial benchmarking tests. The benchmarking results and AREMA guidelines are shown in detailed increments to indicate where performance differences are occurring, as shown graphically in Exhibit 6.

The data shows that evaluations performed on the RDTF are in close agreement with the industry-recommended guidelines.

Improvements in current detection processes or the introduction of new technologies can now be evaluated against baseline results from the benchmarking evaluations performed on the RDTF.

FUTURE WORK

The RDTF is an industry tool used to assure continued progress in rail-flaw detection. Baseline evaluation results documented in

Size (%)	Detection %	Possible	Detected	Not Detected
5	54%	24	13	11
6 to 10	75%	48	36	12
11 to 15	60%	30	18	12
16 to 20	79%	24	19	6
21 to 25	89%	36	32	4
26 to 30	100%	6	6	0
31 to 40	92%	12	11	1
41 to 50	89%	18	16	2
50 to 70	100%	6	6	0
71 to 80	100%	6	6	0

Exhibit 3. RDTF Benchmarking Flaw Hit Percentage (by Size)

Size (%)	Detection %	Possible	Detected	Not Detected
5 to 10	68%	72	49	23
11 to 20	70%	54	38	16
21 to 40	91%	54	49	5
41 to 80	93%	30	28	2
81 to 100	NS	NS	NS	NS

Exhibit 4. RDTF Benchmarking Flaw Hit Percentage (by Size Group)

Size (%)	Category I	Evaluation Mean
5 to 10	65	68
11 to 20	85	76
21 to 40	90	91
41 to 80	98	93
81 to 100	99	No Samples

Exhibit 5. AREMA-to-RDTF Comparison

1998 will be used to compare results of future evaluations of both current and emerging nondestructive evaluation technologies. The RDTF is scheduled for extension during 1999 through funding provided by the AAR and FRA. Member railroads are assisting in identifying flaws in rail for use in the extension of the RDTF track.

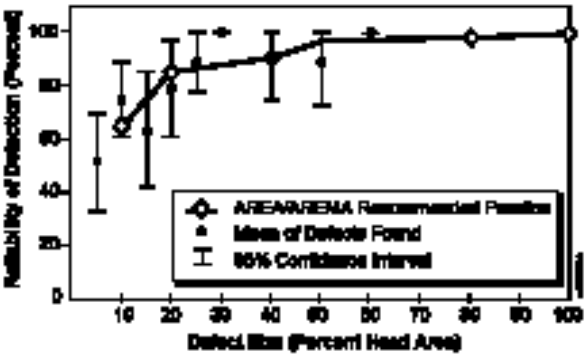

Exhibit 6. Comparison of AREMA Recommended Guidelines to RDTF Benchmark Results

ACKNOWLEDGMENTS

Information generated in this report has been developed through a test program sponsored by the AAR, the FRA, and TTCI. The three major North American rail-flaw-detection subcontractors supplied test cars, test personnel, and rail-flaw-detection expertise during evaluations on the RDTF.

REFERENCES

1. American Railway Engineering and Maintenance of Way Association Manual for Railway Engineering, Section 2.2 “Recommended Minimum Performance Guideline For Rail Testing,” pp. 2-2-4 to 2-2-8, 1997.

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