TECHNOLOGY DIGEST

Timely Technology Transfer

PERFORMANCE OF FROGS UNDER HEAVY AXLE LOADS

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TD 97-018

Summary

Evaluations of turnout frogs indicate that premium components substantially outperform their standard counterparts under both conventional 263,000-pound gross rail load cars and heavy axle load (HAL) cars weighing 286,000 pounds or more. The Association of American Railroads' studies on these components focused on maintenance records obtained from the Union Pacific North Platte Subdivision. The records indicate:

- High-integrity No. 20 rail-bound manganese (RBM) frogs are lasting over three times longer than the standard No. 20 frogs did previously at the same locations.
- Premium spring-rail No. 10 frogs are lasting many more times than the average life of standard RBM No. 10 frogs.
- The improved properties of these premium frogs, compared to standard frogs, more than compensates for the increased loading due to HAL traffic.

The data reflects recent changes in the line including the new construction of several miles of second main track, installation of many new frogs from 1994 through 1996, as well as a change in maintenance policies and procedures as a result of a change in ownership. At this point, there is no data to substantiate a direct correlation between increases in HAL traffic and frog life, weld life, or numbers of repairs, although, as stated above, it is safe to say that the high-integrity frogs compensate for HAL traffic.

This information is from a route that carries only loaded and empty coal traffic. Loaded coal trains generally are not operated on the diverging routes of the turnouts. The Union Pacific is currently using premium-quality spring-rail No. 10 and high-integrity No. 20 frogs to achieve longer frog life on this heavy traffic line. Frog life results could vary on routes with different frog types, traffic mixes, tonnage characteristics and operating and maintenance practices.

Suggested Distribution:

- ❑ Bridges and Roadway
- ❑ Maintenance of Way
- ❑ Maintenance Planning
- ❑ Track Maintenance

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INTRODUCTION AND CONCLUSIONS

As part of the heavy axle load (HAL) implementation program, the Association of American Railroads (AAR) has been monitoring the effects of the introduction of 286,000-pound gross rail-load traffic on the North American railway infrastructure. The program includes monitoring of bridges, turnouts, ties, subgrade, wheel loads, and rate of introduction of HAL traffic. This data is being used to complement that from the Facility for Accelerated Service Testing (FAST). The information is being used to analyze the economic benefits of HAL traffic, as well as to note problem areas quickly, and promote development of improved materials and maintenance practices.

As part of this program, the AAR is monitoring frog life and performance on the Union Pacific (UP) North Platte Subdivision as 286-kip HAL traffic is being introduced. Earlier technical digests (TD 94-001, TD 95-002, TD 96-010, TD 96-012) have reported on the frog life and weld performance on this line for both standard and high-integrity frogs. This digest is an update to those reports.

No. 20 Rail-Bound Manganese Frog Life

Exhibit 1 compares the average life in million gross tons (MGT) of traffic for standard and high-integrity No. 20 rail-bound manganese (RBM) frogs. Since many of the high-integrity frogs are still in service, an estimate (Weibull analysis) was used to account for tonnage still accumulating over those frogs. Frogs removed from service due to line changes are considered as still in service for purpose of this calculation. On average, high-integrity No. 20 frogs are lasting more than three times longer than standard frogs. These results compare well with the experience at FAST, where a high-integrity No. 20 RBM frog lasted 467 MGT under 315,000-pound axle loads.

High-integrity RBM frogs were first installed on this line in 1990 and have been used almost exclusively since about 1992. The estimated mean life of the high-integrity No. 20 frogs has increased each year, indicating that the frog replacement has not yet reached a steady state. High-integrity frog castings have thicker walls, more risers and less porosity as compared to the standard frog castings. Premium rail is used for the wing rails in high-integrity frogs, as compared to standard rail in standard frogs. Other factors, such as improved maintenance practices and the use of heavier base plates with elastic fasteners, joint elimination, gage plates and extended-length guard rails may also contribute to this increased frog life.

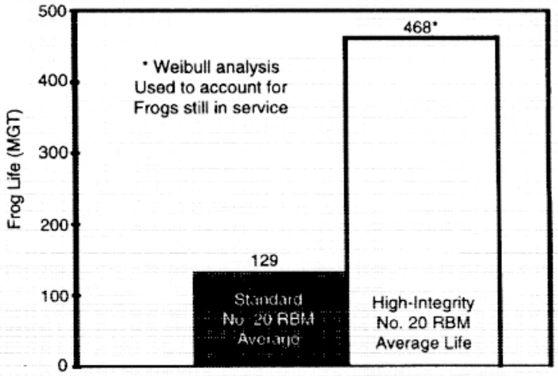

Exhibit 1. No. 20 RBM Frog Life in UP Field Test

Traffic on this line was almost entirely 263,000-pound cars prior to 1993. Since then, the amount of HAL traffic has gradually increased, as shown in Exhibit 2. Approximately 25 percent of the traffic in 1995 was HAL and the percentage has climbed to 37 percent for 1996. Exhibit 2 also shows that the overall traffic on this line has increased over the last five years.

The average life of the high-integrity frogs continues to remain much higher than that of the standard frogs, in spite of the increasing amounts of HAL traffic. Due to the non-steady state nature of high-integrity frog replacement to date, as well as the increasing amount of HAL traffic, it is difficult to isolate the effects of the HAL traffic at this point. However, it is safe to say that the improved properties of the high-integrity No. 20 RBM frogs, compared to standard No. 20 RBM frogs, more than compensates for the higher loads of HAL traffic. The high-integrity frog lives reported here support the experience at FAST.

Exhibit 3 shows that the orientation of a frog with respect to the direction of heaviest tonnage makes little difference in the average life of No. 20 frogs. Tonnage on this heavy-haul route is split about 80 percent in the eastward direction (loads) and 20 percent in the westward direction (empties). For the standard No. 20 RBM frogs, the average life for frogs in facing-point turnouts is slightly less than for frogs in trailing-point turnouts, with respect to the heaviest tonnage direction. For the high-integrity frogs, the average life in the facing-point direction is slightly larger than for high-integrity frogs in the trailing-point direction. The data for this study includes 40 standard frogs and 54 high-integrity frogs. Of the high-integrity frogs, only 14 have failed to date. As tonnage continues to accumulate and additional frogs fail, the average lives may change.

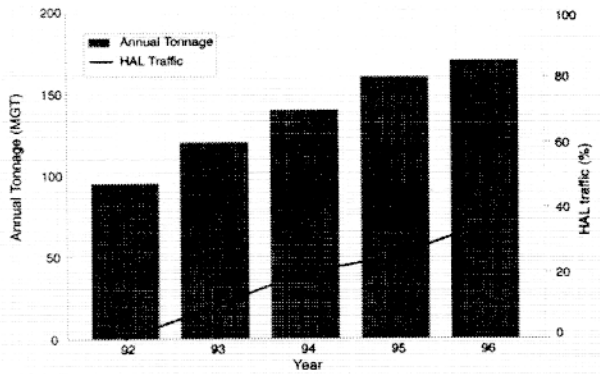

Exhibit 2. Annual Traffic Volume and Introduction of HAL Traffic

No. 10 FROG LIFE

Exhibit 4 shows that two premium No. 10 spring-rail frogs are lasting more than 10 times longer than the average life of the standard No. 10 RBM frogs on this line. Both of these spring-rail frogs are still in service and continue to accumulate tonnage, virtually all on the mainline route. Both of these frogs have seven wingrail hold-downs, as opposed to the three used for a standard American Railway Engineering Association (AREA) design. They also have larger base plates and several braces ahead of the toe. They are protected by 39-foot guard rails on the mainline side instead of the 16.5-foot guard rail for a standard AREA design. The frogs are constructed of fully heat-treated rail, use a flexing wing rail and are fully welded into track with no toe or heel joints.

The premium No. 10 spring-rail frogs, like the high-integrity No. 20 RBM frogs, perform much better than frogs with standard components in heavy-haul service. In spite of increased HAL traffic and train speeds, the lives of premium No. 10 spring-rail frogs remain high. This indicates that for No. 10 frogs, as well as the No. 20 frogs, the use of premium design, materials and improved maintenance practices can make up for the performance degradation due to increasing wheel loads.

Weld Repair Performance

In-track welding repair of rail-bound manganese frogs is a common maintenance practice on high-tonnage lines. These repairs are typically conducted under traffic. In-track repairs create fewer train delays than frog replacement but can require increased labor. Frog maintenance records kept by the welders provide valuable insight into both the frog life itself as well as the nature and magnitude of the repairs.

Because of the operating pattern on this line, the weld repairs occurred almost exclusively on the frog nose and main wing. The side wing, used by diverging route moves, suffered little damage. The loaded trains usually hold the mainline at meets. Hence, only empty trains use the diverging routes. It was observed that the number of nose and wing repairs was about equal.

Exhibit 5 shows the distribution of average interval (MGT) between repairs for the years 1992 through 1996. As the graph indicates, the average interval between repairs for the 1992 through 1994 period was fairly constant (between 18.2 MGT and 24.5 MGT). However, there is a dramatic change in average interval from 1994 to 1995 (24.5 MGT to 56.9 MGT). This dramatic change in MGT between repairs is not likely the result of improved performance, but is related to several operating differences. During late 1994 and most of 1995, several miles of second main track was constructed. As part of this new construction, many new frogs were installed.

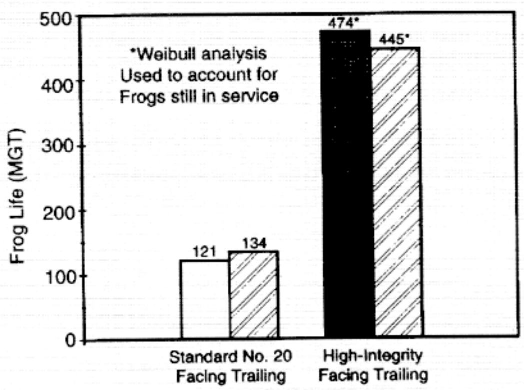

Exhibit 3. Effect of Direction of Traffic on No. 20 RBM Frog Life

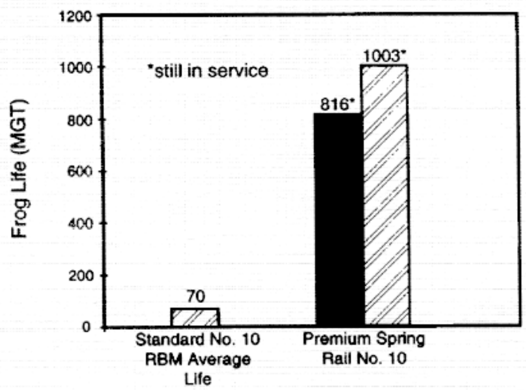

Exhibit 4. Comparison of Average Life for Standard versus Premium Spring-Rail Frogs

This decreased the average frog population age, and resulted in many frogs which needed no repairs due to the fact that they were new. Because of the second main track, many of the frogs that used to carry large quantities of traffic are now only seeing empty cars and don't require maintenance as frequently.

Also during this time period, ownership and operation of the line changed from the Chicago & North Western (C&NW) to the UP. With this change in ownership came changes in maximum allowable train speed, as well as changes in maintenance policy which may have an effect. Because of these factors, it is not yet possible to isolate any effects of HAL traffic on the performance of weld repairs on this line. The data does indicate, however, that to this point, there has not yet been a dramatic increase in frog maintenance requirements due to the increase in HAL traffic.

Examining the volume of repair data in Exhibit 6, a couple of trends become apparent. First, the volume of the repairs made to the main wings is considerably larger (53 percent to 63 percent) than the volume for nose repairs. The difference in repair volume is attributed to frog nose geometry. Secondly, the repair volumes for both the main wing and frog nose decreased from 1995 to 1996 (during which time HAL traffic increased from 25 percent to 37 percent). This decrease in volume is most likely due to the large number of new frog installations associated with the construction of portions of second main track during 1994 and 1995.

BACKGROUND

The data presented in this report are from maintenance records over the last 13 years on this line from Horse Creek, Nebraska, to Shawnee Junction, Wyoming. Speed limit on the line was originally 40 mph in each direction, but has been raised to 60 mph. Over the years, the C&NW and the UP made several improvements in frog maintenance on this line, including installation of longer guard rails, frog gauge plates, larger frog base plates, and elastic fasteners. Tamping, welding, and grinding practices are continuously improving.

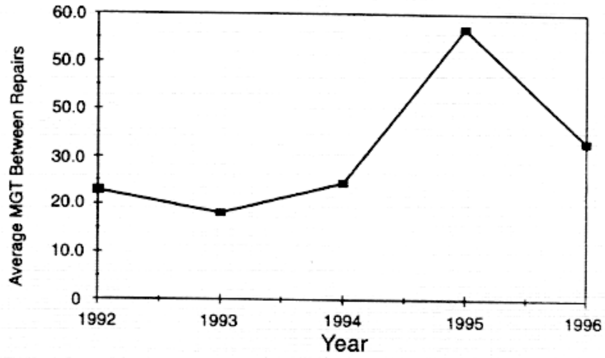

Exhibit 5. Average MGT Between Repairs versus Year

ACKNOWLEDGMENT

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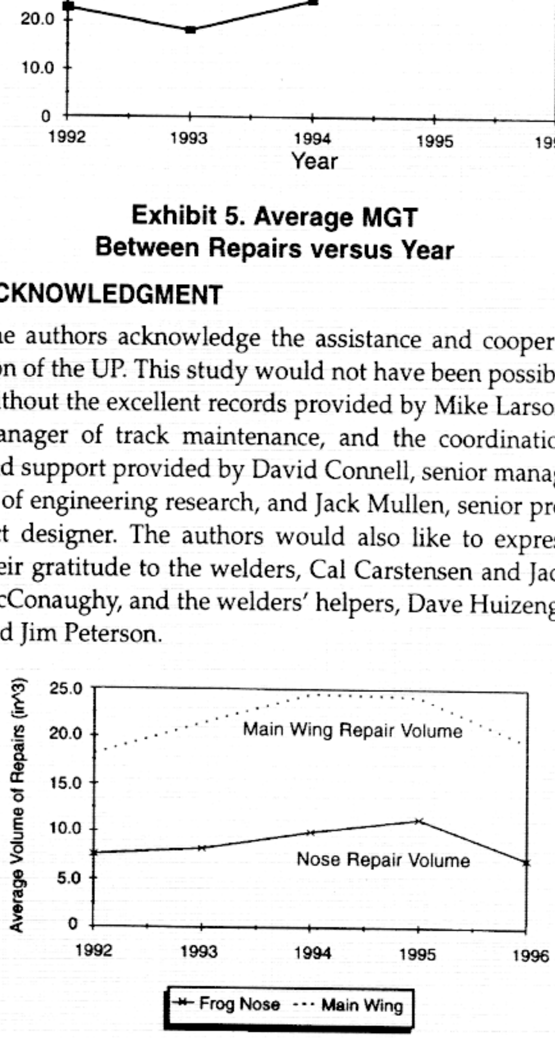

Exhibit 6. Average Repair Volume versus Year

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