TECHNOLOGY DIGEST

Timely Technology Transfer — 99-017

Maintenance Analysis in Revenue Service Under Heavy-Axle-Load Trains

by Ryan McWilliams and David D. Davis

Summary

Although improvements in maintenance practices and component materials have reduced many undesirable effects associated with heavy-axle-load (HAL) traffic, an ongoing revenue-service study by Transportation Technology Center, Inc. has observed undesirable effects associated with heavier axle loads. Most significant is the increase in bridge-maintenance expenditures over a railroad line due to trestle-pile pumping.

Traffic-related bridge expenditures on the Union Pacific's North Platte Powder River subdivision in 1998 tripled those of 1997. Furthermore, nearly 98 percent of the 1998 budget was spent on a single bridge with extreme pile-pumping problems. The UP has taken action to remedy this problem. This result confirms the previous HAL economic studies that stated the effect on bridge costs would be site- (and bridge-design) specific.

Conversely, frog maintenance records provided by the UP show a very positive increase in overall frog life, with approximately 38 percent of total traffic being heavy haul. The No. 20 high-integrity railbound manganese frogs are now surviving 595 MGT before they must be replaced.

While this program is monitoring select maintenance requirements of revenue-service rail lines under HAL traffic conditions, information in this study is for service conditions that complement findings from the Facility for Accelerated Service Testing at the Transportation Technology Center, Pueblo, Colo.

This TD summarizes the performance of the bridge, frog, and wood tie test sites in 1998. The primary areas monitored include: HAL traffic characterization; bridge maintenance expenditures and classification; frog life and wood-tie gage strength.

Previous reports have described these sites in more detail.[1,2,3]

Suggested Distribution:

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

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INTRODUCTION

With the introduction of the heavy-axle-load (HAL) car in 1992, the integrity of the track has been a concern. These issues must be addressed if heavy-axle-load cars are to be introduced to revenue service without economic penalty.

HAL TRAFFIC CHARACTERIZATION

A wayside load station located at Lusk, Wyoming, has monitored freight traffic on the Union Pacific's (UP) North Platte subdivision and provided load information for use in HAL traffic characterization. The overall traffic trend of HAL cars has increased from less than 1 percent in 1992 to a little more than 38 percent in 1998 on this line. This growth rate has slowed in the recent years, with 36 to 38 percent of total traffic being HAL cars for the years 1996 through 1998. The overall traffic increase has also slowed dramatically in the past three years as the line is reaching capacity with only a 4 percent increase in total tonnage since 1996. Exhibit 1 depicts these trends.

Along with overall tonnage information, this load station, which is located on a 1.5-degree curve, has also provided information on single-wheel loads. Exhibit 2 shows a monthly average of lateral and vertical wheel loads at the 50th and 90th percentile. These values are from both 263 -kip and 286-kip cars traveling approximately 40 mph. As shown, the average lateral wheel force increases by approximately 9 percent from a conventional to a HAL car. Furthermore, only 10 percent of the HAL cars that passed this site exceeded a lateral wheel force of 4 kips with the maximum lateral wheel load measured of 9.8 kips.

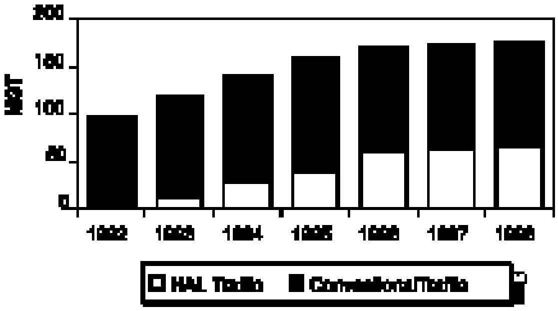

Exhibit 1. Annual Tonnage over Union Pacific's North Platte Subdivision

	Monthly Average		10% Exceedence	
Car Type	Vertical Loads	Lateral Loads	Vertical Loads	Lateral Loads
263 kips	33.8	1.9	35.0	3.9
286 kips	35.7	2.1	37.6	4.0

Exhibit 2. Wheel Loads at 40 mph on a 1.5-Degree Curve

For comparison purposes, a load station at St. Albans, West Virginia, yielded the results of Exhibit 3. This site is located on a 8.4-degree curve and the cars passed at approximately 25 mph with a maximum lateral wheel load measured of 21.5 kips for a HAL car.

The average vertical loads measured at Lusk are good approximations of the average static wheel loads of the cars. Cars in the 286-kip category are weighing about 286 kips when loaded. Cars in the 263-kip category actually weigh about 270 kips loaded. Thus, the 286-kip cars are carrying 111 tons of coal per car, while the 263-kip cars appear to be carrying on average 105 tons of coal per car.

	Monthly Average		10% Exceedence	
Car Type	Vertical Loads	Lateral Loads	Vertical Loads	Lateral Loads
263 kips	29.9	7.0	34.0	14.1
286 kips	32.5	7.4	38.1	15.2

Exhibit 3. Wheel Loads at 25 mph on an 8.4-Degree Curve

BRIDGE MAINTENANCE

Within the past two years, there has been an observable change in bridge-maintenance spending on UP's North Platte subdivision. An increasing amount of trestle-pile pumping has been observed, and this has required a significant amount of maintenance to remedy. The structures most affected appear to be steel H-pile trestle bridges. As Exhibit 4 shows, steel bridges are now significantly more expensive to maintain than are concrete or timber bridges. Prior to the addition of 1998 dollars spent, concrete was the most costly structure to maintain, but only by a small margin. Exhibit 5 shows an increasing portion of the budget being consumed by the pile-pumping problem associated with steel bridges.

Steel bridges are currently the most costly to maintain. Traffic-related bridge expenditures on the North Platte Powder River subdivision in 1998 tripled those of 1997, as shown in Exhibit 6. Furthermore, nearly 98 percent of the 1998 budget was spent on a single bridge with extreme pile-pumping problems. This problem was remedied by UP.

This result confirms the previous HAL economic studies that stated the effect on bridge costs would be site- (and bridge-design) specific.

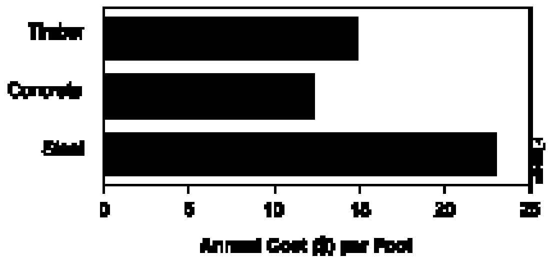

Exhibit 4. Average Annual Bridge-Maintenance Cost by Category on the North Platte Subdivision

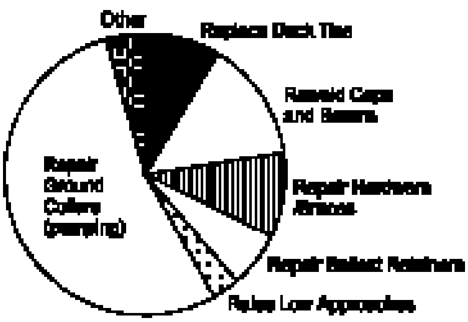

Exhibit 5. Steel Bridge-Maintenance Cost by Category on the North Platte Subdivision

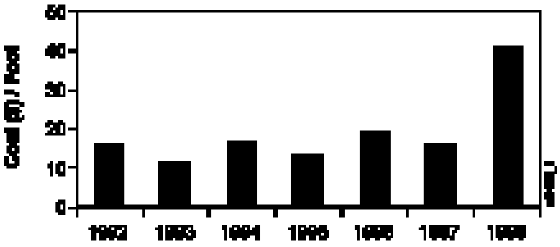

Exhibit 6. Annual Bridge-Maintenance Expenditures per Foot on North Platte Subdivision

FROG LIFE

Turnout-frog replacement has been a category of significant expense for the railway industry. And, under heavier axle loads, one would expect a higher frequency rate of repair and replacement for such special track work. This has not been the case due to a significant improvement in the casting process of No. 20 high-integrity frogs and subsequent incremental improvements in turnout and frog designs.

No. 20 high-integrity frogs were introduced into service in 1990 on the North Platte subdivision. And, although axle loads have increased substantially since the first high-integrity frog was installed, there is still an increase in overall life being observed for this component. Exhibit 7 shows that there has been a dramatic increase in frog life for those frogs installed since 1994. Using Weibull analysis, the average life of frogs installed since 1994 is now 595 million gross tons (MGT). With 28 of the 41 frogs in this study still in service, the average life continues to rise.

During the 1990-1998 analysis period, the average time to first (weld) repair has remained

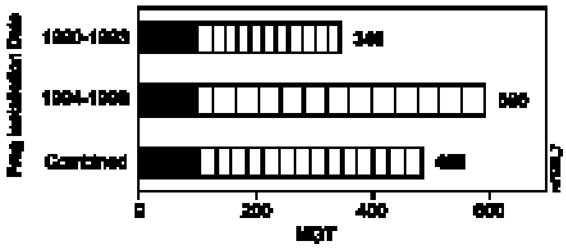

Exhibit 7. Frog Life by Installation Date on North Platte Subdivision

constant at 100 MGT. The longer life of recently installed frogs is due to longer life of weld repairs. And while those installed between 1990 and 1993 are averaging 22 MGT between repairs, frogs installed between 1994 and 1998 are lasting 39 MGT between repairs after the initial repair is made. This being the case, there appears to be a consistent number of repairs made on any given frog during its life; but those installed most recently are lasting longer between repairs than those installed just a few years ago.

It may be of interest to note that the No. 10 spring-rail frog being monitored at the Lusk yard has been removed from service after accruing more than 1,300 MGT.

WOOD-TIE GAGE STRENGTH

The HAL Revenue Service program has also monitored gage strength on a 5.1-degree curve at Oakvale, West Virginia, over a Norfolk Southern heavy-haul line. This effort has observed gage strength of wood crosstie track with cut-spike fasteners as well as with elastic fasteners. Exhibit 8 shows measured track gage under the static, laterally loaded and unloaded conditions. The lateral load is applied by a hydraulic ram that applies up to a 10-kip load in 2-kip increments.

The elastic fastening system installed in 1995 was replaced in 1998 with AREA 18-inch plates and cut spikes due to excessive tie-plate cutting. Although the elastic system retained gage very well, a rate near .128 inch per 100 MGT, the tie-plate cutting was significant enough to warrant replacement.

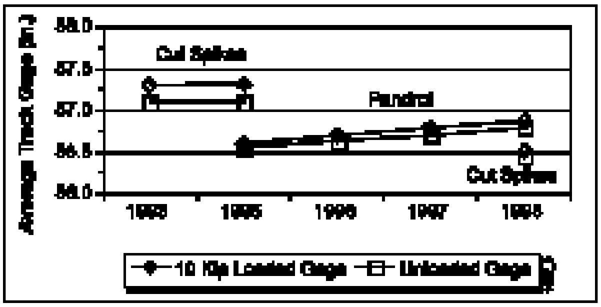

Exhibit 8. Track Gage over Wood Ties at a 5.1-Degree Curve

CONCLUSIONS AND FUTURE EFFORTS

Although strides are being made to improve track conditions and reduce maintenance spending, there are still many areas where progress can be made.

Our future efforts are going to focus on problems related to high maintenance-cost issues, along with foreseeable areas of opportunity. This may include bridge-approach issues as well as the monitoring of 315-kip cars.

REFERENCES

1. Trevizo, C. et al. "Interim Report on the Effects of the Introduction of Heavy Axle Loads in Revenue Service" R-Report No. R-916, Transportation Technology Center, December, 1997.

2. McWilliams, R., Otter, D., "Bridge Maintenance Analysis Under Heavy Axle Load Trains in Revenue Service" *Technical Digest* No. 98-024, Transportation Technology Center, September, 1998.

3. McWilliams, R., Davis, D., " Effects of Heavy-Haul Traffic on Turnout Components in Revenue Service" *Technical Digest* No. 98-019, Transportation Technology Center, August, 1998.

ACKNOWLEDGMENT

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Note: Contact Ryan McWilliams at (719) 584-0757 with questions or comments about this document.

E-mail: ryan_mcwilliams@ttci.aar.com

Web site: www.ttci.aar.com

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