TECHOLOGY DIGEST

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Performance and Life Cycle Cost Comparisons for No. 20 Turnouts in HAL Service

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Summary

A study comparing the performance and life cycle costs of No. 20 turnouts in a 315,000-pound car, 40 mph Heavy Axle Load (HAL) environment indicates that there has been much improvement in the performance of turnouts during the 1990s. This study, conducted by Transportation Technology Center, Inc (TTCI), shows a 50 percent reduction in required maintenance hours at the Facility for Accelerated Service Testing (FAST). While some increase in component life has been seen at FAST, the small sample of turnouts makes quantification of the trend difficult.

Comparison of the long-term performance and maintenance requirements of No. 20 turnouts has been conducted at FAST, where four turnouts were monitored over the last 10 years. These turnouts represent a wide range of designs and features in service today. Conclusions include:

- The cost of maintaining No. 20 turnouts for HAL service (as measured in labor hours at FAST) has decreased due to improvements over 1980 technology from about 2.1 hrs/million gross ton (MGT) to 1.0 – 1.2 hrs/ MGT.
- Use of a low-entry angle switch has caused an increase in switch maintenance as compared to American Railway Engineering and Maintenance of Way Association (AREMA) geometry switches. As previously reported,[1] the low entry angle switch has been effective in lowering the maximum lateral force by about 30 percent, as compared to AREMA geometries. However, the thin section curved switch points are failing sooner in the FAST/HAL environment.
- The cost of manganese casting spring frog maintenance versus rail bound manganese (RBM) frog maintenance is about the same in the FAST operating environment. This environment has a high percentage of diverging traffic (about 46 percent). This mitigates the advantage of spring frogs in eliminating the flangeway gap for mainline traffic. The types of maintenance needed differ by frog design.
- An economic analysis of the FAST No. 20 turnouts shows that the low entry angle switch, spring frog turnout with 46 percent diverging traffic has a life cycle cost that is 8 percent more than the AREMA geometry, RBM frog.

The TTCI study results are applicable to operations similar to the High Tonnage Loop at FAST, a HAL unit train operation, where up to 150 MGT of 315,000-pound traffic is operated annually. Car and wheel maintenance are good, with relatively few “hollow tread” wheel wear profiles as compared to revenue service.

Suggested Distribution:

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

Work performed by TTCI Transportation Technology Center, Inc.
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INTRODUCTION

The following analysis of No. 20 frog maintenance was conducted using data available from the heavy axle load (HAL) experiment at FAST. The FAST turnouts see an unusually severe load environment as compared to revenue service. Among the differences are:

- Wheel Load: 39 kips maximum versus 33 to 36 kips in revenue service. Train speed is constant at 40 mph.
- Percent loaded cars: 100 percent at FAST versus 60 percent in revenue service. In mixed freight service, many cars are loaded to less than 100 tons (33-kip wheel load).
- Percent diverging traffic: 45-50 percent at FAST versus 10-25 percent in typical revenue service.
- Large-scale fleeting of trains: 150-250 trains in the same direction and route at FAST versus 5-10 in same direction and route on most revenue service lines.
- Better wheel profile conditions; fewer hollow worn profiles.

FAST TURNOUT PERFORMANCE UNDER HAL

Maintenance records have been collected for the No. 20 turnouts in service at the High Tonnage Loop (HTL) over the past 10 years. These include turnouts that were standard in the pre-286 kip car era of the early 1980s to modern late 1990s standard turnouts. Also tested was a low entry angle switch that is a hybrid of American Railway Engineering and Maintenance of Way Association (AREMA) and full tangential geometries. The records show how much improvement there has been in turnout design to reduce maintenance. The required maintenance for No. 20 turnouts under HAL traffic has fallen by about half thanks to the introduction of new technologies following the 1980s. Exhibit 1 lists the maintenance required for recent No. 20 turnouts in FAST.

Exhibit 2 shows the maintenance hours for each turnout by category. Note that frog and switch maintenance constitute only about one half of the total for the turnouts. In absolute terms, the maintenance required for turnouts under 39-kip wheel load traffic has decreased since FAST began testing designs built for 33-kip wheel load service in 1988.

Also note that Exhibit 1 is a “snap shot” of the maintenance rates for the two turnouts still in service at FAST. As such, the rates will change as maintenance is needed and components fail. The rates will change most for the railroads’ current standard turnout since it has not had a major component replacement (e.g., frog, switch point) yet. The long-term maintenance rate for this turnout is probably higher than what is presented here. However, the low entry angle switch, spring frog turnout has recently had a frog and switch point replacement. Thus, its current maintenance rate is probably higher than its long-term maintenance rate.

PERFORMANCE OF SWITCHES

As previously reported, the low entry angle switch tested has been effective in reducing maximum lateral loads in a No. 20 switch.[1] The low entry angle switch, with an entry angle that is about half that of an AREMA switch, has maximum lateral forces that are about 33 percent lower than the AREMA switch. However, this switch has not been economical in the FAST environment due to the short life of the curved switch points.

The low entry angle switch point has a thin section that has failed by chipping out in the first 6 feet from the point. The life of curved (i.e., diverging route) points in this turnout is 163 MGT as compared to a curved point life of 250 MGT in the AREMA geometry turnouts. The lives of straight (i.e., main route) switch points was similar between the two designs. The average life of AREMA geometry straight switch points was 348 million gross tons (MGT) versus 333 MGT for the low entry angle switch. With no benefits assigned to the improved ride quality and no capacity improvements

FAST NO. 20 TURNOUT DESCRIPTION	DATE INSTALLED	TOTAL TONNAGE (MGT)	TURNOUT MAINT. (HRS/MGT)	COMP. REPL. (HRS/MGT)	TOTAL MAINT. & REPL. (HRS/MGT)
Low entry, Spring	1998*	335	0.81	0.38	1.19
1980s Std (AREA, RBM)	1988	107	1.42	0.65	2.07
1990 Prm Matl (AREA, RBM)	1992	683	0.85	0.19	1.04
RR Current Std (AREMA, RBM)	1999*	204	0.55	0.07	0.63

* turnout is still in service

Exhibit 1. FAST No. 20 Turnout Maintenance History

FAST NO. 20 TURNOUT	DATE INSTALLED	FROG MAINT. (HRS/MGT)	SWITCH MAINT. (HRS/MGT)	OTHER MAINT. (HRS/MGT)	COMP. REPL. (HRS/MGT)	TOTAL MAINT. & REPL. (HRS/MGT)
Low entry, Spring	1998*	0.28	0.11	0.42	0.38	1.19
1980s Std	1988	0.58	0.72	0.12	0.65	2.07
1990 Prm Matl	1992	0.16	0.09	0.59	0.19	1.02
RR Current Std	1999*	0.29	0.03	0.23	0.07	0.63

*** turnout is still in service**

Exhibit 2. FAST No. 20 Turnout Maintenance by Category

made by raising allowable speed through the low entry angle turnout, there is a life cycle cost increase due to the shorter average switch point life.

PERFORMANCE OF FROGS

The use of spring frogs in FAST versus the use of premium RBM frogs is also not economical based on our limited sample of frogs. This is due to the nature of the operation at FAST with 46 percent of the traffic using the diverging side of the turnout. All diverging traffic was operated at 40 mph, a very atypical situation as compared with revenue service. The spring frog failed from damage to the running surface on the diverging or fixed wing side. The life of the frog was governed by the behavior of the fixed wing. Thus, it is not surprising that spring frog life, at 335 MGT, was similar to FAST RBM frog life (300-350 MGT). The spring frog did provide performance benefits in lowering, but not eliminating, impacts for mainline traffic.[1] There was some small reduction in maintenance required as compared to FAST RBM frogs (about 3 percent). However, the decrease in maintenance is not nearly sufficient to repay the initial cost premium of the spring frog over the RBM frog.

The maintenance required for spring frogs in FAST is roughly equivalent to the maintenance required for RBM frogs. The character of that maintenance changes with frog type. There is less welding and grinding per MGT with the spring frog due to the reduction in impact forces for traffic on the mainline side of the frog. There is additional maintenance (not seen in RBM frogs) in the moving parts of the frog, such as rollers and retarders. Use of an effective retarder would reduce the maintenance of the moveable wing and improve the economics of the spring frog.

The FAST operating environment presents an adverse scenario for spring frogs in that almost half of the traffic is diverging and, thus, does not benefit from the closed mainline flangeway. In this adverse scenario, the spring frog requires about the same amount of maintenance hours as the RBM frog.

ECONOMIC ANALYSIS OF FAST SITUATION

Economic analysis of the life cycle costs of each turnout type was done using the initial cost of each turnout, the major component lives, the maintenance costs incurred, and a discount rate of 10 percent. Track occupancy/train delay cost was also considered in the analysis by assigning a cost of $120 per hour for each hour the turnout was out of service for maintenance. The results suggest that the low entry angle, spring frog turnout has a 14 percent higher life cycle cost than the AREMA geometry, RBM frog turnout when track occupancy is considered. For the FAST situation, where track occupancy cost was considered to be zero, the low entry turnout has 16 percent higher life cycle costs. While the AREMA turnout requires less maintenance, it requires more track occupancy time to maintain than the low entry, spring frog turnout.

EFFECT OF DIVERGING TRAFFIC

Predictions of switch point life versus diverging traffic were made using the actual life of switch points in FAST as measured by actual tonnage over the component. For example, the average life of curved switch points was 163 MGT for the low entry angle turnout and 250 MGT for the AREMA geometry turnout. With 46 percent diverging traffic, the actual tonnage over the diverging route was 75 MGT and 115 MGT respectively. Exhibit 3 is a plot of the amount of turnout tonnage versus percent diverging traffic to reach the switch point lives seen at FAST. In all cases, the low entry angle switch is at a relative economic disadvantage due to the shorter curved point life.

In order to assess the performance of spring frogs in more typical operations, we apportioned the maintenance accumulated by the FAST spring frog to the traffic on the mainline side and the traffic on the branch line side of the turnout as listed in Exhibit 4. This is based on engineering judgment since we did not record the location of grinding or weld repairs on the frog.

Using this damage factor relationship, estimates were made for the maintenance requirements of a

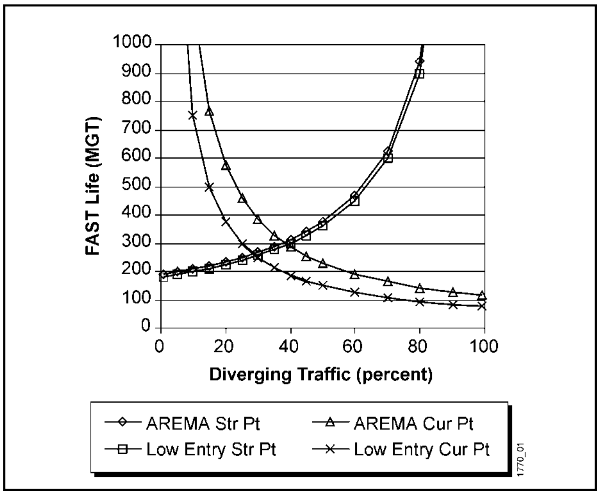

Exhibit 3. Predicted FAST Switch Point Life Versus Percent Diverging Traffic

Maintenance	Diverging Traffic (%)	Mainline Traffic (%)
Grinding	80	20
Weld Repair	80	20
Surfacing	66	33
Spring Wing	100	0

Exhibit 4. Apportionment of Maintenance to Traffic Route

spring frog in FAST with various amounts of diverging traffic. Exhibit 4 lists the results of this study. The actual results obtained for the 46 percent diverging traffic case at FAST (28 hours per 100 MGT) agree closely with the apportionment devised. Exhibit 5 is a plot of the analysis results.

Exhibit 6 is a plot of the predicted life of each frog type under HAL traffic versus percent diverging traffic. The relationship is based on the expected life of the fixed wing of the frog from the FAST test and the experience of railroads in revenue service applications.

The economics of spring frogs for HAL service appear to improve significantly as diverging traffic decreases below 35 percent. The optimal frog for each situation will depend on several factors not considered in this study. They include:

- Initial cost of each frog type
- Ride quality considerations
- Track maintenance costs
- Service reliability/train delay costs
- Track availability for maintenance

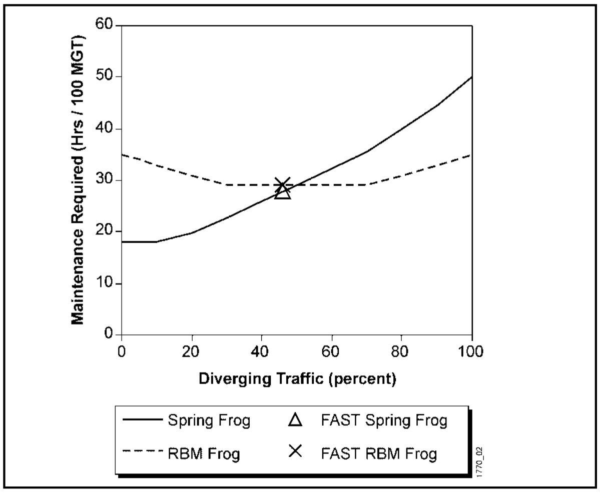

Exhibit 5. Predicted Maintenance Requirements for FAST No. 20 Frogs Versus Percent Diverging Traffic

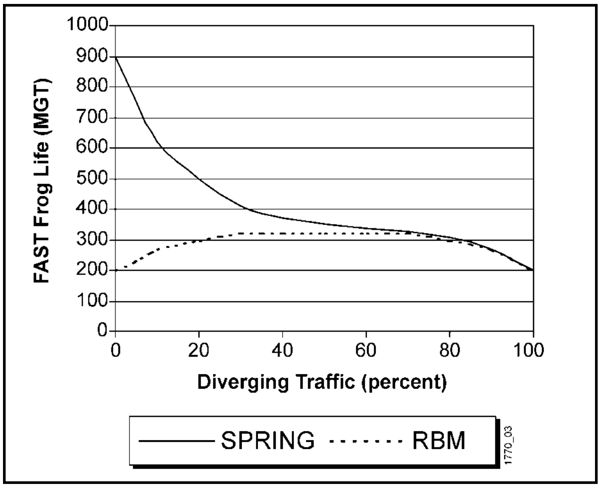

Exhibit 6. Predicted Frog Life under HAL Versus Diverging Traffic

REFERENCES

1. Davis, D., and Guillen, D., "Comparison of Performance of AREMA and Intermediate Geometry Design Turnouts," Transportation Technology Center, Inc., Technology Digest 99-021; December, 1999.

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