TECHNOLOGY DIGEST

Timely Technology Transfer

ECONOMICS AND SELECTION OF TAMPING METHODS AND PRACTICES

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TD 97-023

Summary

Technology Digest "Economic Comparison of Conventional, Continuous Action, and Design Lift Tamping," TD 96-016, issued in June 1996, initiated a comparison of tamping costs and practices (particular emphasis was placed on the potential benefits of the concept of design lift tamping). The limited scope of that comparison raised several questions and encouraged us to develop a broader economic analysis. Recent studies using an economic model by the Association of American Railroads developed a more systematic approach for quantifying and comparing costs of tamping methods under different situations. The results of these studies are presented in this digest.

This study produced the following main conclusions:

- Where production tamping is required, such as after a tie or ballast renewal, the economic model predicts a cost savings for increasing tamping speed.
- In general, tamping only those spot locations needing geometry correction can provide significant savings compared to the practice of production tamping.
- The design lift tamping method is predicted to be the most economical choice for spot tamping when the spot locations reoccur on a yearly (or more frequent) basis. Conventional tamping practices are more economical for spot locations that reoccur over a longer period.
- As the spacing between the rough spots decreases, there is a point at which it becomes more economical to use production tamping, rather than spot tamping.

Cost sensitivity analysis shows that the addition of ballast material during tamping operations represents the largest per-track-mile cost component and largely dominates the predicted outcome. When appropriate to use, spot tamping adds new ballast only where needed; therefore, it has a significant cost advantage compared to a production tamping practice of adding ballast along the entire track section.

Tamper productivity (machine speed) was considered in the analysis by using both "fast" and "slow" versions for conventional tamping and design lift tamping. While beneficial, tamping speed had a relatively minor effect on the 10-year per-track-mile present value cost.

Suggested Distribution:

- ❑ Research and Test
- ❑ Maintenance of Way
- ❑ Maintenance Planning
- ❑ Planning and Analysis

Association of American Railroads
Research and Test Department

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INTRODUCTION AND CONCLUSIONS

A previous study that compared the costs of tamping techniques and practices (TD 96-016) has been expanded to answer questions raised following its publication; in particular, to correctly portray the comparative advantage of fast tamping in design lift applications. An enhanced economic model was developed in this latest study which provides a systematic approach to quantify and compare the costs of tamping methods under different situations. This more detailed analysis offers an improved method for an evaluation of the most economical tamping choice.

The study offers the following major conclusions:

- If the design lift method of spot tamping is used, a benefit is predicted whenever it provides at least 1.8 times more durable smoothing than conventional tamping. Testing by AAR and British Rail has shown that design lift tamping is often 2 to 3 times as durable as conventional tamping.
- The tamping speed, within the range considered and using the assumptions stated below in the analysis, has a relatively minor effect on cost. The tamping method is the dominant factor with the ballast costs being the main driver.

ASSUMPTIONS

The economic analysis estimates the 10-year present value of the per-track-mile costs of four tamping strategies. An annual discount rate of 11 percent is used throughout the analysis, and no federal or state tax income effects are considered. Equipment costs include all ownership and maintenance costs, including capital recovery. The cost of labor required to operate the equipment during the tamping activity is added. All tamping strategies incur an initial production tamping expense at "time zero." After this initial expense, each tamping strategy incurs its relative cost based on its tamping cycle within the 10-year time horizon.

The following tamping methods were considered:

- Conventional Tamping (CT)
- Fast Conventional Tamping (FCT)
- Design Lift Tamping (DLT)
- Fast Design Lift Tamping (FDLT)

Although only the first two methods are commercially available, CT or FCT machines could be modified to provide DLT[1] or FDLT.

The assumptions pertaining to each of the four tamping methods are as follows.

1. Production Rate:
   CT - *1,600 feet per hour*
   FCT - *4,200 feet per hour*
   DLT - *1,070 feet per hour (2/3 of CT Rate)*
   FDLT - *2,800 feet per hour (2/3 of FCT Rate)*
2. Tamping Requirement per Spot to be Tamped:
   All methods - *250 feet (100-ft run in, 50-ft rough zone, 100-ft run out)*
3. Number of Tamping Spots per Mile:
   All methods - *0.25, 0.50, 1.0, 2.0, 3.0, 4.0*
4. Travel Time in Hours Between Tamping Spots (listed in order of the number of tamping spots per mile indicated above):
   CT - *0.18, 0.10, 0.06, 0.04, 0.03, 0.02*
   FCT - *0.09, 0.05, 0.03, 0.02, 0.015, 0.010*
   DLT - *0.18, 0.10, 0.06, 0.04, 0.03, 0.02*
   FDLT - *0.09, 0.05, 0.03, 0.02, 0.015, 0.010*
5. Production Hours Available per Shift
   All methods-*6 hours (8-hour shift, 2 hours travel, wait and prep time)*
6. Ballast Requirements -
   CT and FCT - *20 tons per spot* (250-ft. zone)
   DLT and FDLT - *30 tons per spot*
7. Ballast Material Cost: *$10/ton* (as delivered and placed)
8. Tamp Cycle - Cases considered for all methods - *6 mos, 1 year, 4 years*
9. Endurance Multiple - (increase in time between tamp cycles provided by DLT or FDLT over CT or FCT)
   CT and FCT - *1 on all analyses*
   DLT and FDLT - *1, 2, and 3 times conventional* (based on limited field experience)
10. Equipment Costs (includes all operating costs, less labor, plus maintenance and capital recovery)
    CT - *$835/day*
    FCT - *$2,000/day*
    DLT - *$1,250/day*
    FDLT - *$2,000/day*
11. Labor Requirement: *2 people per shift*
12. Labor Cost (includes hourly wages + fringe benefit): *$20/hour/per person*

It is assumed that the FCT tamper would already have the necessary equipment to perform the design lift function and would require minimal or no cost to upgrade. In this analysis, no additional cost is assumed.

Spot Tamping Versus Production Tamping

The economic model was used to consider if it is more cost effective to tamp only those sections of track that require surfacing (spot tamping) or to tamp continuously throughout a long section, including track that is not in need of geometry correction (production tamping).

Production tamping is appropriate after a ballast or a tie renewal where the track has been disturbed over long sections. However, this may or may not be an economical practice for a surfacing cycle where tamping is the only goal of the maintenance.

To compare these practices, a "base case" was developed for production tamping using FCT — *the ballast requirement was increased to 420 tons/mile to give a continuous 1-inch track raise. Only the case of a 4-year tamp cycle was considered.*

The base case 10-year present value cost for production tamping a mile of track on a 4-year cycle, with the above assumptions, was estimated to be $9900/track-mile. The cost of spot tamping, which varies with the number of spots per mile (Exhibit 1), is much less than production tamping even when as much as 20 percent of the track is tamped (4 of the 250-foot spots per mile). Production tamping may be more economical if the individual track faults are very close to each other; e.g., with the run-in and run-out transitions tamping zones being very close to each other. Although the rough spot spacing at which it becomes more economical to switch from spot to production tamping is left unquantified in this analysis, it is recognized that such a feature exisits. To obtain this "cross over" point would require further site specific assumptions and additional analysis. Otherwise, it appears more economical to choose spot tamping between major rehabilitation cycles.

The reason for the outcome in Exhibit 1 can be shown by performing a sensitivity analysis with the economic model. As shown in Exhibit 2, the amount and cost of ballast has the dominant effect upon the predicted outcome. Therefore the reduced ballast requirement with spot tamping produces a correspondingly large savings. Also note that the cost is predicted to be relatively insensitive to machine speed, equipment costs and labor due to the dominance of ballast costs.

Note that the practice of reducing ballast costs by tamping with track raises of less than 1 inch ("skin lifts") is not advocated. This procedure may not provide the needed ballast placement under the tie to ensure a stable track raise and smoothing. Also, the analysis assumes that track occupancy is not a factor; i.e. that all methods are working within a given "work window" when no trains are scheduled. However, if the tamping operations are affecting traffic and if the cost of track possession is high, a faster tamping method will show an additional benefit.

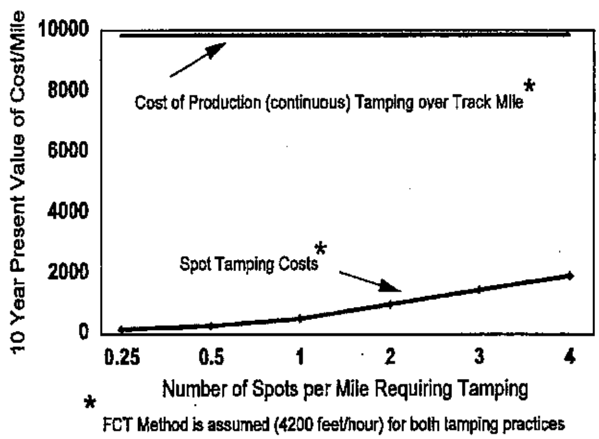

Exhibit 1. Cost Comparison between Production and Spot Tamping

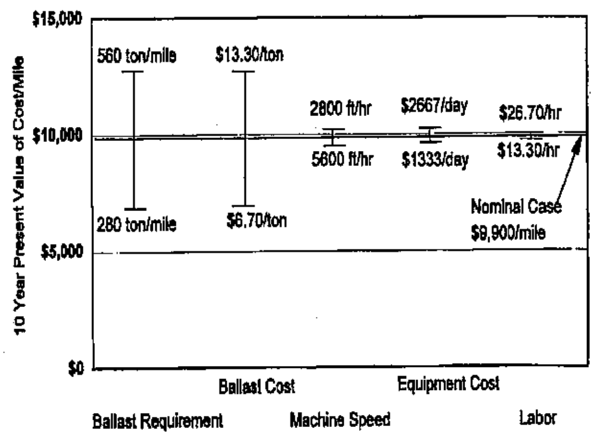

Exhibit 2. Cost Sensitivity for Production Tamping of a 1-Track Mile with FCT Method on a 4-Year Tamp Cycle

MOST ECONOMICAL METHOD OF SPOT TAMPING:

Conventional or Design Lift

An economic analysis was also performed to determine which of the four tamping methods is the most cost effective spot tamping technique, and under what conditions.

For spots that require tamping on a frequency of about one year or less, the DLT method is predicted to provide a savings compared to the cost of CT. The amount of savings depends mainly on the number of spots per mile that will require tamping over this time period and the increase in tamping durability resulting from DLT (the endurance multiple). Endurance multiples of 2 to 3 appear to be a reasonable expectation based on a limited amount of field testing.[1] Exhibits 3a and 3b show the predicted 10-year present value costs for the four tamping methods based on a 6-month spot tamping cycle and endurance multiples of 2 and 3 respectively.

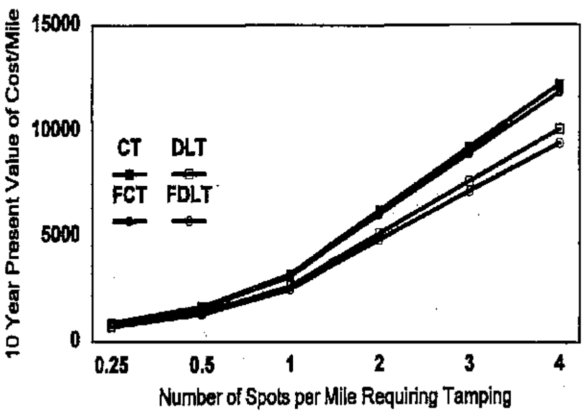

Exhibit 3a. Cost Analysis of Various Spot Tamping Techniques for 6-Month Tamping Schedule and an Endurance Multiple of 2

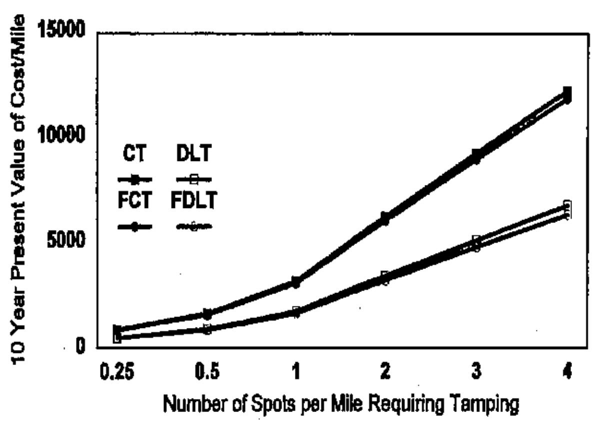

Exhibit 3b. Cost Analysis of Various Spot Tamping Techniques for 6-Month Tamping Schedule and an Endurance Multiple of 3

As illustrated, ballast cost has a dominant effect, perhaps masking the influence of other variables. If we were to set aside ballast costs, and assume four spots per mile of required tamping with an endurance multiple of 1 (no advantage to design lift tamping), the 10-year present value tamping costs for machinery and labor for CT, FCT, DLT, and FDLT are estimated at $1,760, $1,065, $2,810, and $1,990, respectively. If the design lift endurance multiple were 3, the costs for DLT and FDLT change to $990 and $700, respectively. (The costs for CT and FCT are the same as there is no endurance multiple change for conventional tamping techniques.) Thus, the model not only provides an estimate of faster tamping equipment advantages, but it also shows that these machinery speed advantages are consistent for both conventional and design lift techniques. For any given set of conditions, the model can be used to indicate the "break point" for the various methods.

DLT is not expected to be significantly more durable than CT for spot locations that require tamping over a longer cycle of several years. This is because most of the track settlement that occurs over a short time following tamping is due to ballast resettlement. Such short-term ballast re-settlement can be controlled by the design lift process unless the subgrade is weak and deforming rapidly. When the ballast re-settlement duration is a year or less, endurance multiples of 3 or more appear to be possible. But for longer periods, even a relatively stable subgrade can deform considerably and contribute a significant portion to the overall track settlement, thereby masking the improvement due to controlled ballast settlement provided by DLT. Because DLT is not expected to offer a significant increase in smoothing durability over this longer term, CT or FCT would then be the most economical tamping method for spot tamping locations which require tamping on cycles of once every several years.

Most Economical Method of Production Tamping

Where the track requires production tamping, such as after a ballast or tie renewal, increased tamping speed provides the most economy. For a four-year production tamp cycle, the economic model predicts the 10-year PV cost per track-mile for CT to be $10,200 and $9,900 for FCT. This is based on a four-year tamp cycle. As mentioned, the DLT method is not considered to be appropriate for production tamping.

REFERENCE

1. Chrismer, S.M., D.M. Johnson, M.C. Trevizo and J. LoPresti. *Technology Digest* TD 95-024, Association of American Railroads, Nov. 1995.

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