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Loaded Tank Car Test in Revenue Service

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Summary

Transportation Technology Center Inc. (TTCI) conducted an accelerated test program in revenue service to investigate the role of track geometry and operating speeds on loaded tank car dynamic performance. Using measurements from approximately 3,700 miles of revenue service tests, TTCI developed Performance Based Track Geometry (PBTG™)¹ models for a loaded tank car, deployable with the real-time PBTG™ system and PBTG™ office system. The results showed that tank car response to wide-ranging track and operating conditions was found to be generally within prescribed performance limits. Dynamic response exceeded limits at only two locations.

This work was conducted by TTCI under the Association of American Railroads Strategic Research Initiatives (SRI) Program. BNSF Railway (BNSF), and Canadian National Railway (CN) supported the tests on selected crude oil routes. BNSF provided the buffer cars throughout the test, and locomotives and manned track geometry cars were provided by BNSF and CN as testing was conducted on the BNSF or CN railroad. TrinityRail supplied the tank car used for the test. The test was conducted over a five-week period over 3,700 miles of track. Dynamic response and track geometry data were simultaneously collected for the entirety of the revenue service test.

The dedicated test train consisted of a locomotive, five consecutive buffer loaded cars (286,000-pounds GRL), a DOT-111 loaded test tank car with disabled brakes, ASF Motion Control trucks fitted with Pennsy adapter pads and with variably damped suspension, filled with water to standard interchange 286,000-pound GRL weight with 15 percent outage, and the AAR-112 test car (which was used for data acquisition purposes), a support car, and a manned track geometry car, provided by BNSF and CN while testing on their respective railroads.

To automatically help process and synchronize the distance-based track geometry measurements and the time-based tank car response, a computer utility was developed. The utility has GPS mapping features and can handle large datasets from various measuring systems. For the entire 3,700 miles tested, only two track locations were identified over which exceedances, as defined per AAR Chapter 11² criteria, occurred. The first exceedance occurred at a crossing diamond at 25 mph, where the lateral to vertical (L/V) ratio and vertical forces of the lead truck exceeded the prescribed thresholds. Such a high dynamic response was expected as crossing diamonds tend to always generate significant responses independently of the vehicle type. The other track location was at a road crossing at 50 mph, when only a B-end carbody vertical acceleration exceeded the corresponding limit. The exceedance was due to the transition as track stiffness changed. Apart from those two locations, the tank car did not generate vehicle/track interactions that were of significant concern. Therefore, developing a real-time PBTG™ model was deemed unnecessary, and an office PBTG™ model was developed instead.



INTRODUCTION

TTCI designed and conducted an accelerated test program to determine the load environment of a loaded tank car in revenue service. BNSF Railway, and Canadian National Railway (CN) supported the test on selected crude oil routes and TrinityRail supplied the tank car used for the test.

A special test train was put together, which consisted of a locomotive, five consecutive buffer loaded cars (286,000-pounds GRL), a DOT-111 loaded test tank car with disabled brakes, and the AAR-112 test car (which was used for data acquisition purposes), a support car, and a manned track geometry car, provided by BNSF and CN while testing on their respective rail systems. Figure 1 shows the test train while testing in revenue service.



Figure 1. Test Train in Revenue Service Testing

INSTRUMENTATION

The following instrumentation was used:

- Two 36-inch instrumented wheelset (IWS) systems installed on both lead truck axles (car A-end)
- One instrumented coupler installed at the lead-end of the tank car to provide longitudinal force data
- Two tri-axial accelerometers installed on the car draft sill at A- and B-end of the tank car, and biaxial accelerometers on the un-sprung side frames of the lead truck
- Spring nest vertical displacement bending beams for lead and trailing trucks

Figure 2 shows some of the instrumentation equipment used for the test. It should be noted that the brakes on the tank car were cut out and the handbrake was disabled to protect the electronics on the IWS, which are prone to damage from the thermal loads expected from normal braking operations, and to avoid any chance of creating flat spots on the IWS tread surfaces from wheel slides.

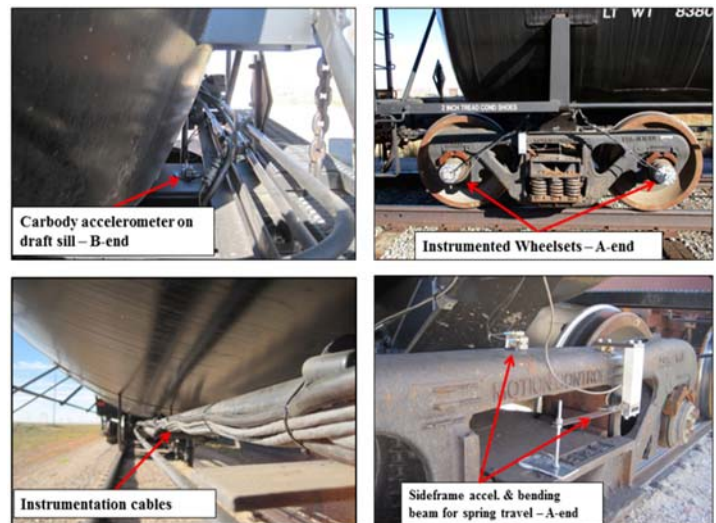


Figure 2. Instrumentation Details

INSTRUMENTATION CHECKOUT

Before the over-the-road (OTR) test began, performance testing for the tank car and a functional checkout of the instrumentation was conducted over selected AAR Chapter 11 test zones at TTC.²

All the transducers performed as expected during the test and were cleared for revenue service testing. Figures 3 and 4 illustrate the tank car response examples as the car traveled over the Chapter 11 twist and roll, and pitch and bounce perturbation zones.

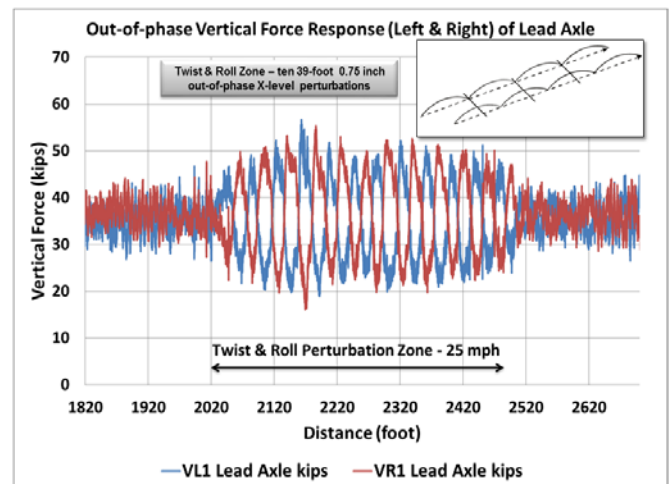


Figure 3. Twist & Roll Zone Car Response

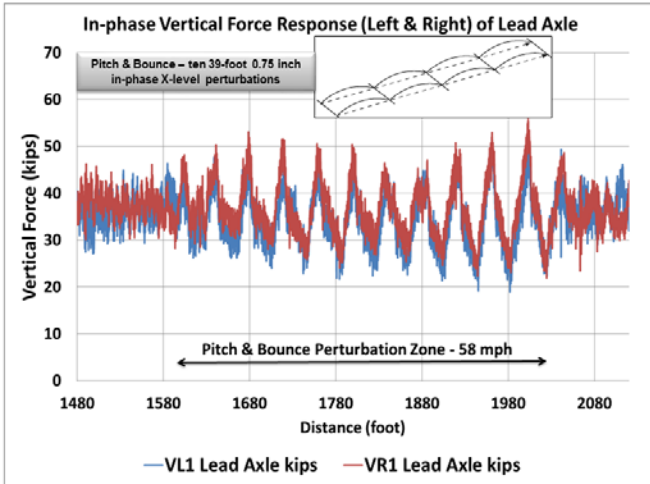


Figure 4. Pitch & Bounce Zone Car Response

REVENUE SERVICE TESTING ROUTES

The tank car traveled over mostly crude oil routes selected by the participating railroads. Figure 5 shows (in red) the 2,350-mile route the test train traveled on BNSF trackage from Pueblo, Colorado, to Joliet, Illinois, which was completed in three plus weeks.

Then, the test car interchanged with CN in Joliet in the Chicago area, and began another testing phase on CN tracks. Figure 6 shows (in red) the 1,350-mile test routes the test train traveled, which was completed in two weeks.

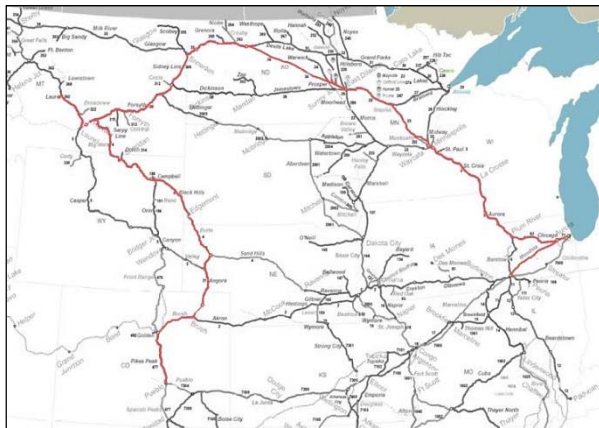


Figure 5. Test Routes with BNSF



Figure 6. Test Routes with CN

PERFORMANCE EXCEPTIONS

For the entire test, the tank car dynamic response to wide-ranging track and operating conditions was within the prescribed performance limit. Figure 7 shows a summary of the single wheel L/V ratio observations, as recorded on 2,350 miles of the BNSF system. A track location causing L/V ratio at a single wheel to exceed 1.0 would have been considered an exception track location requiring maintenance attention. Similarly, Figure 8 summarizes the L/V ratio as recorded on 1,350 miles of CN trackage.

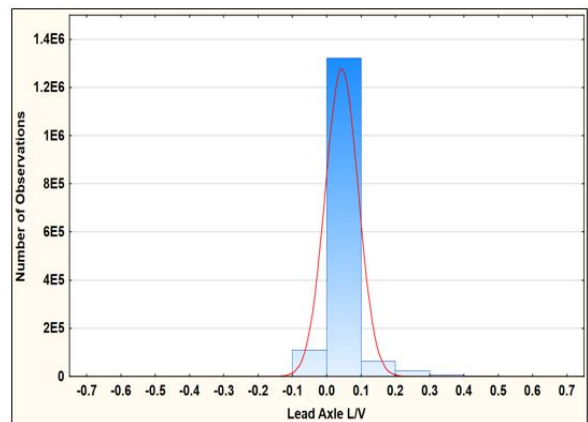


Figure 7. Lead L/V - BNSF Tracks

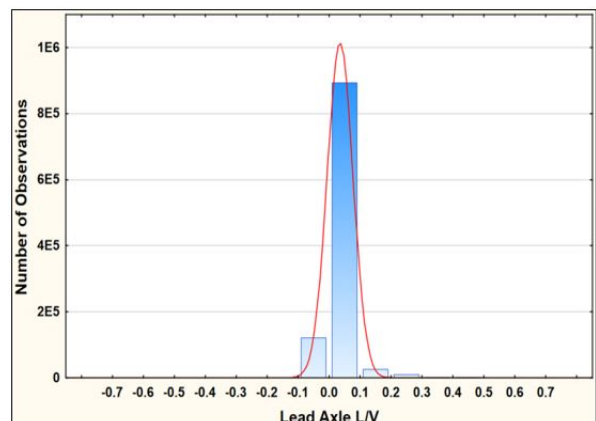


Figure 8. Lead L/V - CN Tracks

Using Chapter 11 criteria, only two track locations were identified over which exceedances occurred. The first location was at a crossing diamond at 25 mph, L/V ratio and vertical forces of the tank car lead truck exceeded prescribed thresholds, as shown in the time history plot in Figure 9 (circled in red). The other location, as shown in Figure 10, was a road crossing at 50 mph, a B-end carbody vertical acceleration exceeded the prescribed performance limit.

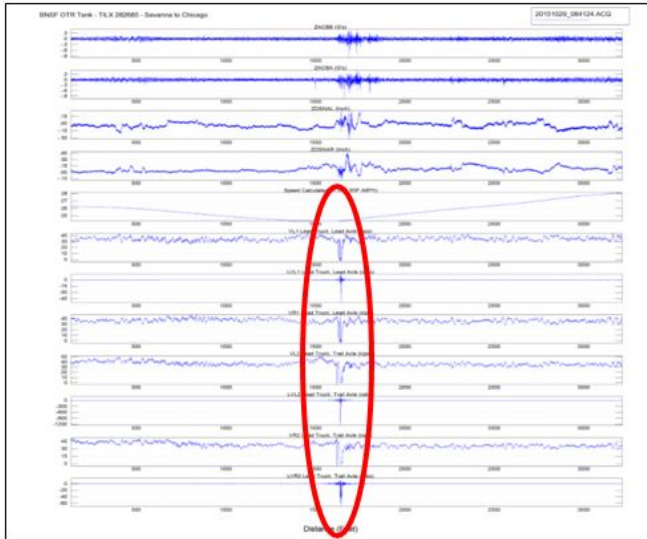


Figure 9. Dynamic Exceptions over Diamond Crossing

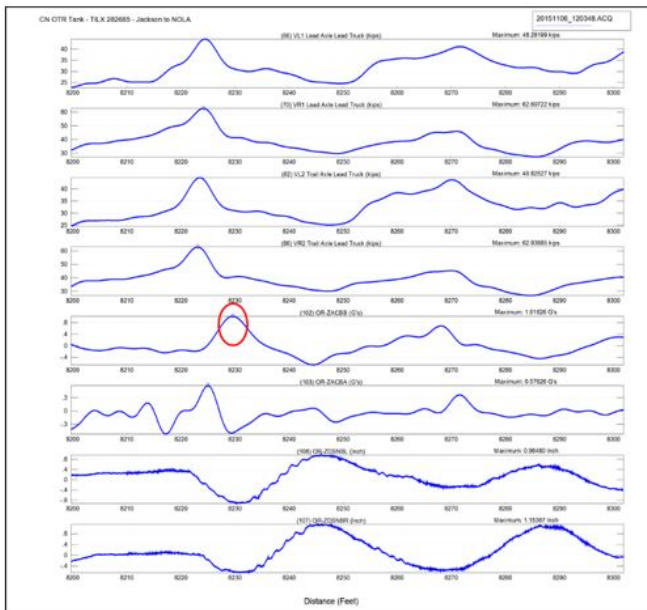


Figure 10. Vertical Carbody Exception over Road Crossing

LOADED TANK CAR PBTG™

Given the tank car response observed in revenue service, it was decided that a real-time PBTG model that could be used onboard track geometry vehicles was not needed. Therefore, a PBTG™ office system model was developed instead. Using historic geometry data, the office PBTG™ can be used to reveal the vehicle/track interaction relationships, patterns, trends, and identify track locations with a likelihood of generating adverse car response.

CONCLUSIONS

Test results for a loaded DOT-111 tank car tested in revenue service for 3,700+ miles on BNSF and CN routes showed:

- Vehicle dynamic response to wide-ranging track and operating conditions was generally within prescribed performance limits
- Dynamic response exceeded limits in only two locations: expectedly at a crossing diamond, as crossing diamonds tend to always generate high dynamic responses regardless of the vehicle type, and at a grade crossing, due to the transition as track stiffness changed
- Therefore, developing a real-time loaded tank car PBTG™ model was deemed unnecessary and an office PBTG™ model was developed instead.

ACKNOWLEDGEMENT

TTCI thanks BNSF, CN, and TrinityRail for their support.

REFERENCES

1. Li, Dingqing, Abe Meddah, Kevin Hass, and Semih Kalay. "Development and implementation of performance-based track geometry inspection." *Proceedings of Railway Engineering Conference*, London, UK, 28–29 June 2005 (ECS Publications, Edinburgh, UK).
2. Association of American Railroads. *AAR Manual of Standards and Recommended Practices*, Section C-II, Design, Fabrication and Construction of Freight Cars, M-1001, Chapter 11 "Service-worthiness tests and analyses for new freight cars." Washington, DC. 2015.

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