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Overloaded Trucks Increase the Stress State of Railroads

by Ken Rownd

Summary

Tests of a coal car that was overloaded on one end demonstrated that this condition is not desirable for the track structure. The load tested was selected to represent actual load conditions observed from wayside vertical force measurements in a single month at two railroad service sites.

Two coal cars were tested in 3,000 miles of railroad service in 2005 to document the wheel loads, wheel strains, carbody strains, and carbody accelerations. These 286,000-pound gross rail load cars were loaded with approximately 143,000 pounds on the rail at each car end. At the request of the railroads, additional testing was conducted at the Transportation Technology Center (TTC), Pueblo, Colorado, to measure the effect of overloading one end of one of the same cars. The total weight of the car was 286,000 pounds; however, the heavy end was loaded to 160,000 pounds and the light end was 126,000 pounds.

The tests described here are in support of the general railroad industry initiative to reduce the stress state. Several years of railroad research and development has been focused on making the track stronger and reducing the dynamic loads by improving the vehicles. One of those improvements was the development of a suspension performance specification referred to as M-976. This specification became effective in July 2004 and is mandatory for cars built new, rebuilt or upgraded to 286,000- pound gross rail load for operation in unrestricted interchange service. Cars loaded to 286,000 pounds prior to the implementation of M-976 could only be interchanged by agreement with the handling railroads. The car tested here is one of the older designs. The M-976 specification does exercise the suspensions under "worst case" car types; however, tests are performed with the cars loaded symmetrically.

The railroad industry is using wayside measurement systems to identify problem cars. Some of these systems measure vertical wheel force making it possible to establish a history of car weights and load distributions. The AAR *Manual of Standards and Recommended Practices* states that each end of the car should weigh no more than half of the total car weight limit. Since coal cars are usually loaded in motion this rule may be impractical. Overloading a truck to 160,000 pounds is at best equivalent to allowing 320,000 pound interchange cars. This weight increase is not desirable for the track structure.

Testing shows that dynamic loads can be increased beyond that expected from just increased weight. This is due to the suspension capacity being inadequate to control vehicle response to track features such as road crossings, switches, track geometry deviations, or vehicle performance.

Overloaded truck vertical test results measured a dynamic load factor of 3.0 (475,000 pounds) in conditions designed to excite carbody bounce. One end of a properly loaded car in the same test generated a dynamic load factor of 2.6 (371,000 pounds). If the overloaded truck dynamic factor were held to 2.6, a maximum vertical force of 416,000 pounds would have been observed.

A thorough study of the effects of overloaded trucks is planned for next year's industry research program.

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INTRODUCTION

Railroad industry research and development has focused on reducing the stress state in the railroad system. These efforts have resulted in stronger track and in vehicles that reduce forces applied to the track structure.

In 2004, the industry adopted a standard that increased the allowable interchange car gross rail load from 263,000 pounds to 286,000 pounds. Many railroads were already operating at the increased weight on their own property and by special agreement between individual railroads. The new standard allows unrestricted interchange of the heavier cars by requiring better truck performance. The suspensions for new or rebuilt cars in the heavier service must now meet the performance requirements of M-976 (Truck Performance Specification to Qualify Suspensions for 286,000-pound Interchange Service). Although M-976 tests are conducted with "worst case" cars, testing is always done with symmetrical loads.

It has been observed by the railroads and from wayside measurements at truck performance detector sites that cars sometime get overloaded on one end or on both ends. The tests described here are a first effort to understand the effect of improper car loading on the stress state. One load condition was tested. This load condition was established by looking at vertical force data from two railroad detector sites for one month. A more through study will be conducted in future years.

BACKGROUND

In 2005, a 3,000-mile test was conducted in railroad service to measure wheel loads, axle strains, carbody strains, and carbody accelerations. Two coal cars were instrumented and tested in the front end of a revenue train. The cars were loaded at a mine with an approximate total weight of 143,000 pounds at each car end. At the request of the railroads, one of the cars was tested at TTC with symmetrical loading and with one end overloaded. (Figure 1 shows the test cars. They were aluminum body cars, but did not have M-976 approved suspensions.)

Figure 1: Coal Cars Tested at TTC

A single improperly loaded condition was tested at TTC. The selected weights of 160,000 pounds on one end and 126,000 pounds on the other end represent the upper limit of the measurements taken at the two wayside locations.

OBSERVATIONS AND RESULTS

The B-end of the car was tested with 143,000 pounds weight and with 160,000 pounds of weight. Comparing these cases the following conclusions were made:

General observation:

- Overloading a truck will increase the lateral and vertical forces imparted to the track.
- The practical upper bound for overloaded trucks must be determined including consideration of economic and operational impact.

In tests designed to excite carbody bounce:

- The maximum vertical truck load was 371,000 pounds for the properly loaded truck and 475,000 pounds for the overloaded truck.
- Increased load was due to heavier initial weight and to an increase in the dynamic load factor.
- Maximum carbody vertical acceleration was 1.83 g on the 160,000 pound end and 1.29 g on the 126,000-pound end.

In tests designed to excite carbody roll:

- The maximum vertical wheel load measured was 85,000 pounds for the 160,000 pound truck and 76,000 for the 143,000 pound truck.
- Wheel lift was documented for the properly and improperly loaded cars.
- Normalizing the dynamic loads measured for the 160,000 pound truck by the ratio of the weights (143,000/160,000) made the maximum loads equal. This indicates that the increased vertical loads were due to weight change alone. The dynamic load factor was not increased.

In dynamic curving tests designed to investigate curving performance while carbody roll is excited:

- The maximum vertical wheel load for the properly loaded truck was 70,000 pounds. The maximum for the 160,000-pound truck was 78,000 pounds.
- The minimum vertical load was 6,500 pounds for the 143,000-pound truck and 5,000 pounds for the 160,000 pound truck.
- Lateral to vertical (L/V) force ratios were acceptable for both load conditions.
- Normalizing the vertical and lateral loads measured for the 160,000-pound truck by the ratio of the weights made the maximum loads equal. This indicates that the increased vertical loads were due to weight change alone. The dynamic load factor was not increased.

WAYSIDE DATA FOR TRUCK WEIGHTS

To determine a realistic upper limit for end-to-end miss loading, one month of wayside data was examined at two railroad sites. Figure 2 shows the truck weight history. A few trucks had loads as large as 160,000 pounds. These represent less than 1 percent of the total trucks measured. To bracket the potential overload situation, it was determined that the test weight at TTC should be 160,000 pounds on one end and 126,000 pounds on the other end.

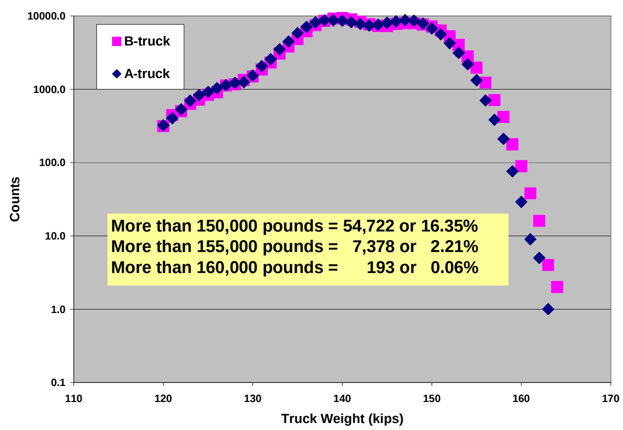

Figure 2: History of Truck Weights

TESTING FOR BODY BOUNCE RESPONSE

The cars were tested over a section of track designed to initiate body bounce response. Suspensions, such as these, which were purchased prior to performance specification M-976 do not have a maximum acceleration criterion.

As reference, the M-976 specification requires that suspensions must limit body accelerations to less than 1.0 g in this test. The test initiates behavior that could be induced from track features such as road crossings, switches, or vertical deviations in track geometry.

The properly loaded car has truck weights of 143,000 pounds each. The improperly loaded car had one truck weighing 160,000 pounds.

Figure 3 shows the maximum (total-truck) vertical load for the properly loaded truck and for the overloaded truck. Also shown is the overloaded truck data with loads normalized by the ratio of the truck weights (ratio = 143,000/160,000). As shown, normalizing by weight explains just part of the vertical force increase. The rest of the increase is due to loss of suspension capacity.

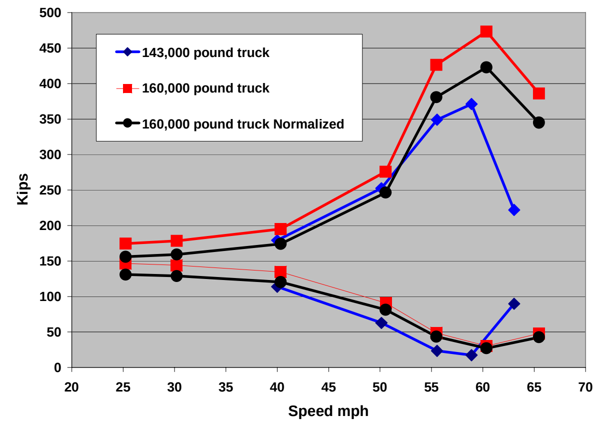

Figure 3: Maximum Vertical Loads in Bounce Tests

Figure 4 compares the vertical body accelerations for the 126,000- and 160,000-pound ends. The 126,000-pound end was trailing. Even in the under loaded condition of 126,000 pounds, the vertical acceleration exceeded 1.0 g.

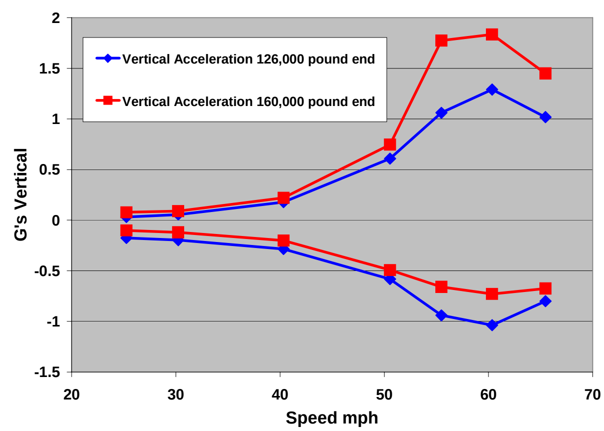

Figure 4: Vertical Accelerations in Bounce Test

TESTING FOR BODY ROLL RESPONSE

During body roll testing, the vertical loads were increased by a percentage approximately equal to the percent change in static weight. This indicates that the suspension capacity has not been exceeded for the overloaded truck in the roll tests. Normalizing the 160,000-pound truck data by the ratio of the weights shows that the dynamic augment in roll is nearly the same as that observed in the 143,000-pound truck tests. Figure 5 shows the maximum vertical loads during the body roll tests.

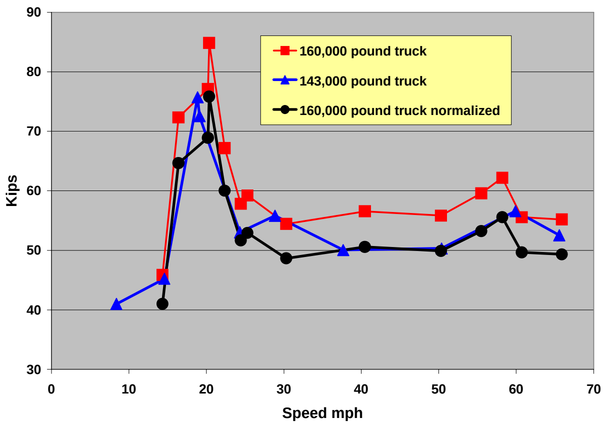

Figure 5 : Maximum Vertical Load in Roll Tests

Roll test results did not meet the minimum vertical wheel load criterion. Figure 6 shows the minimum wheel loads (sustained for 50 msecs) compared to the 10-percent criterion for the 143,000-pound truck. Both truck weights exhibited wheel lift near 20 mph.

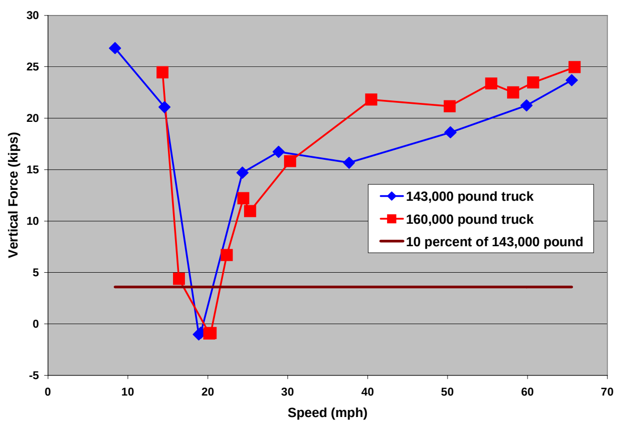

Figure 6: Minimum Vertical Wheel Load in Roll Tests

TESTING FOR DYNAMIC CURVE RESPONSE

The dynamic curve zone is designed to initiate roll response while negotiating a 10-degree curve. As observed in the carbody roll test results, the dynamic curve data indicates a force increase for the overloaded condition, but normalizing by weight reveals that the dynamic load factor was not increased. The overloaded truck suspensions were still functioning in this test regime.

Figure 7 shows the maximum vertical wheel force and Figure 8 shows the maximum lateral force in dynamic curving for the 160,000- and 143,000-pound trucks. Minimum vertical load and maximum wheel L/V were acceptable for both truck loads.

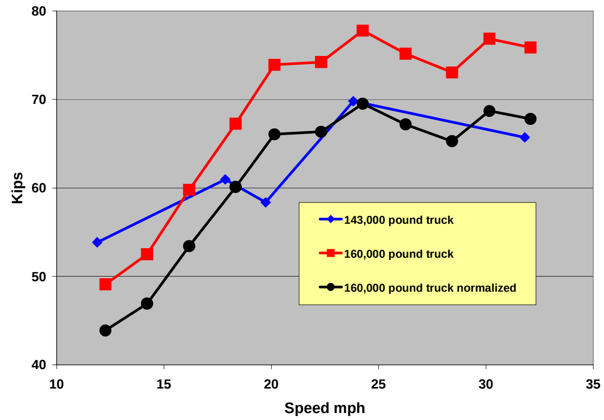

Figure 7: Maximum Vertical Load in Dynamic Curving

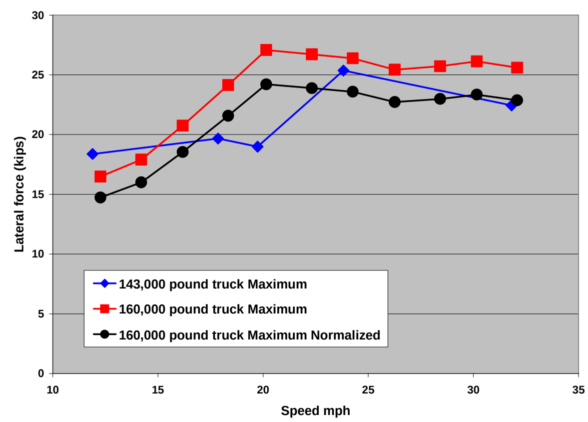

Figure 8: Maximum Lateral Force in Dynamic Curving

SUMMARY

Overloading one or both ends of a coal car will have an adverse effect on car performance and result in increased loads on the track structure. In roll response tests, it appears that the increase in vertical loads is directly proportional to the increased weight. In bounce response tests, the increase in vertical loads exceeded the increase in weight indicating that the suspension capacity has been exceeded.

At best, loading one end of the car to 160,000 pounds is equivalent to raising the current interchange standard from 286,000 pounds to 320,000 pounds. Performance of track components and track maintenance costs will be negatively affected.

Practical limits for overloaded trucks will be investigated by a future railroad research initiative. This initiative must consider the implications of overloaded conditions on the track structure and the practical problem of what is appropriate action when overloaded trucks are identified.