TECHNOLOGY DIGEST
Timely Technology Transfer

"TRUCK CHARACTERIZATION TESTS PERFORMED ON SERVICE WORN CARS,"

by Curtis L. Urban and Huimin Wu

TD 94-009

Summary

Recent truck characterization tests conducted at the Transportation Test Center, Pueblo, Colorado, on five service worn car sets of variable damped trucks showed that the vertical suspension travel is affected by wedge rise. As the wedge rises, the available travel can be reduced due to friction wedge lock-up and binding. This loss of vertical suspension travel can correspond to about 1/2 the amount of the wedge rise. The friction wedges lock-up prior to the load coils going solid.

A few years ago, outer bolster gibs were wearing significantly in service. Gib clearance was subsequently increased to prevent contact with the side frame in order to reduce or eliminate the wear. At the time, this may have seemed to be a good idea, but inspections of service worn trucks show it was a costly modification. The outer gib wear has now been transferred into internal lateral bolster pocket wear. The modification is causing serious hidden wear patterns and metal plastic flow to develop on the outboard side walls of the bolster wedge pocket. These wear patterns are not allowing the friction snubbing system to work properly.

Association of American Railroads
Research and Test Department
June 1994

TECHNOLOGY DIGEST
June 1994

INTRODUCTION AND CONCLUSIONS

The Mechanical Division Sub-Committee on Research steered the Association of American Railroads (AAR) into two major goals: (1) to examine the overall problems associated with 100-ton standard three-piece truck designs, and (2) to recommend maintenance guidelines that would optimize and improve the standard three-piece truck's performance.

In 1989 and early 1990 the AAR developed a specially designed instrumented truck to investigate the relationship between wear and performance. A combination truck was selected to allow for either variable or constant damped designs to be tested. The truck was modified to test various levels of simulated wear by effectively reducing the column damping. In 1991, on-track tests were conducted over several perturbed track sections using the variably damped instrumented truck for two states of wear. The results from these tests were inconclusive indicating that the instrumented truck may not be simulating the worn truck condition typically seen in revenue service.

In 1992, five matching car sets of 100-ton variable damped truck designs were obtained from a member road to further understand how truck performance is affected by wear. The trucks were characterized for vertical, laterally, and warp damping and stiffness parameters using the Mini-Shaker Unit in the Transportation Test Center's Rail Dynamics Laboratory. Friction wedge rise, a common indicator of wear, for these trucks ranged from 0.4 inch to 1.7 inches. The manufacturer suggests that the trucks be reconditioned at 0.75 inch of wedge rise when approximately 50 percent of the friction damping remains.

Vertical Characterization Test Results

All of the 100-ton trucks were exercised through their full available suspension travel using new and worn D5, inner, outer load coils, and double side control coils. The available vertical travel of the suspension coils was 3 11/16 inches. Exhibit 1 shows the results of suspension travel using new D5 coils.

In Exhibit 1, the available travel of the vertical suspension is plotted against friction wedge rise. The correlation between available travel and wedge rise is clearly seen. A regression line has been added for easy interpolation of the results.

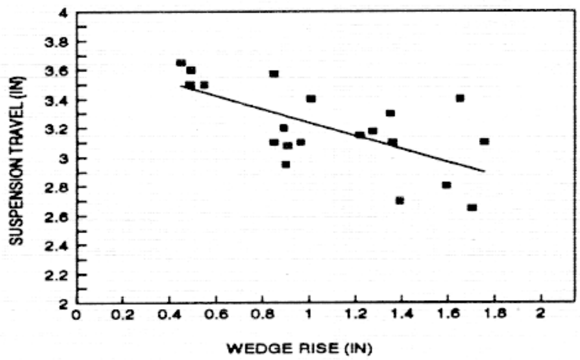

Exhibit 1. Suspension Travel vs Friction Wedge Rise

Notably if the D5 coils were replaced with longer travel coils, the results would have been similar; i.e., wedge binding would reduce the overall suspension travel. The friction wedges are locking up the suspension prior to the D5 coils going solid. Exhibit 2 shows the mechanism for wedge lock-up as determined from observations and truck inspections.

Exhibit 2 also shows a side view of the truck bolster, friction wedges, and side frame wear plates. The top diagram of Exhibit 2 illustrates the normal wear pattern for these trucks in the loaded condition. As might be expected for a variably damped truck, the most amount of wear occurs when the truck is in loaded configuration. Normal vertical and lateral motion between side frame and bolster creates a three-dimensional concave wear pattern to develop on the surface on the side frame wear plates and a conformal convex wear pattern on the surface on the friction wedges. It also creates a mechanical stop along the bolster slope face in the pocket.

The bottom diagram in Exhibit 2 shows what occurs when the truck is stroked beyond the normal loaded range due to a high dynamic load. The wedges must slide down the bolster slope face and rotate toward the bolster to allow for vertical motion. Due to the wear patterns on the bolster slope face, the wedge can only slide down and rotate a slight amount. Eventually the wedge locks up the suspension due to binding prior to the suspension reaching its normal solid displacement.

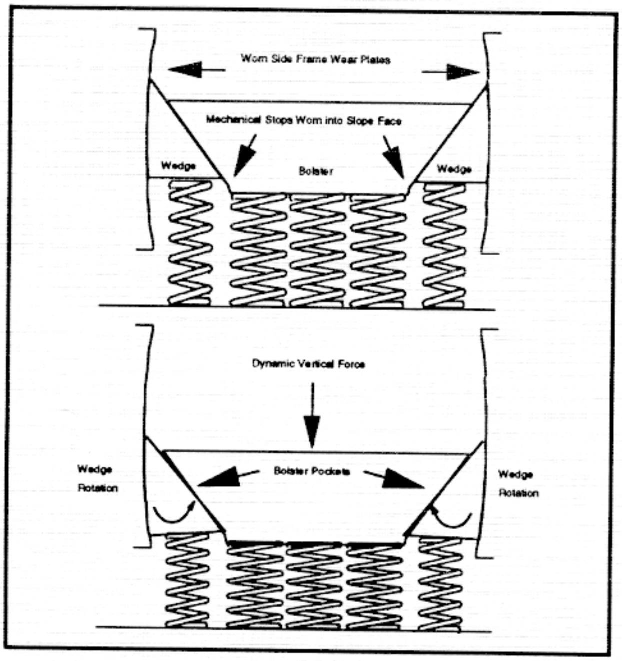

Exhibit 2. Mechanism for Loss of Travel Due to Friction Wedge Lock-up

Exhibit 3 shows the correlation between vertical truck damping and wedge rise. Total vertical truck damping is plotted against vertical wheel loads for various wedge rise conditions.

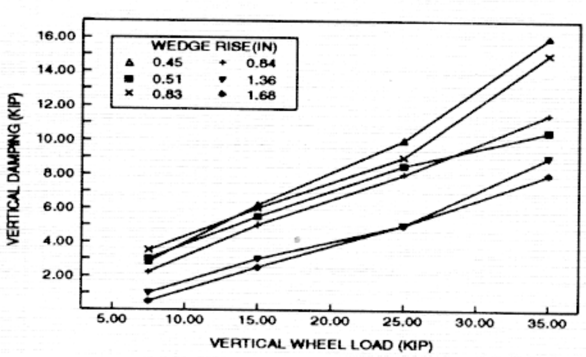

Exhibit 3. Vertical Suspension Damping vs Vertical Wheel Load

Lateral and Shear/Warp Characterization Test Results

The trucks were exercised through their full lateral suspension travel using four loaded configurations: 7,500, 15,000, 25,000 and 35,000 pounds wheel loads. Data presented in Exhibit 4 shows the correlation between total lateral truck damping and wedge rise. The trucks showed a similar trend when exercised through their full shear/warp suspensions using the same loaded configurations.

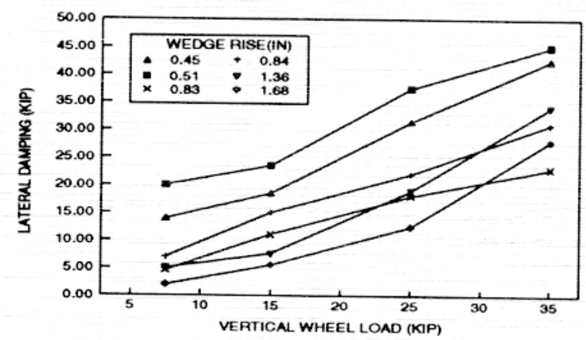

Exhibit 4. Lateral Suspension Damping vs Vertical Wheel Load

Truck Inspections

From the truck inspections, a number of critical observations were made. A major finding is reported as follows:

Depicted in Exhibit 5 is the mechanism that is causing increased lateral wear in the bolster pocket side wall area due to the non-symmetric gib spacing. The top and bottom diagrams show the end view of the side frame, bolster wedge pocket, and friction wedge. As discussed in the summary, gib clearance was increased during the design of these trucks to reduce wear.

In the bottom diagram of Exhibit 5, the bolster has been displaced laterally. With larger lateral displacements, the control coil eventually becomes angled. The force in the control coil is then reacted in the vertical and lateral directions. This causes a moment to be set up on the friction wedge, which in turn must be reacted on the side frame wear plate and the bolster wedge pocket side walls. As the truck is stroked vertically, the force in the control coil increases. This causes a larger moment to be reacted on the side frame wear plate and bolster wedge pocket side walls.

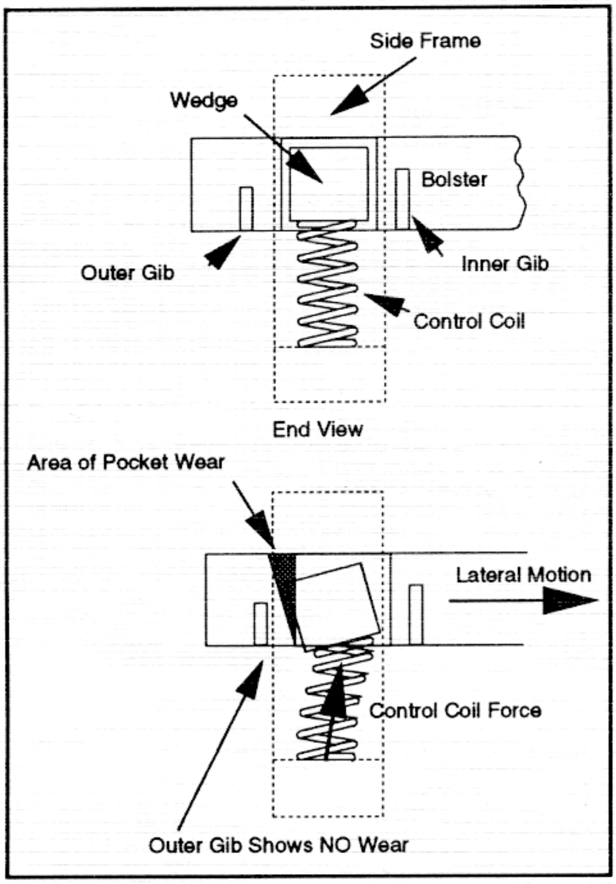

Exhibit 5. Mechanism Depicting Damage Due to Moving Outer Gib

If the lateral and vertical displacements are small, the moment on the wedge can be reacted by a friction moment on the side frame wear plate. However, the maximum value of this moment is limited by the available friction. As the lateral and vertical displacements increase, the friction wedge can no longer react this moment, which in turn must be reacted on the side walls of the bolster wedge pocket. As the truck suspension is stroked vertically, the reacted moment on the side wall eventually causes a wear pattern to develop on the bolster side wall as depicted by the shaded region in the lower diagram of Exhibit 5. This wear pattern has been observed on these trucks and is over 0.5 inch wide at the top and 0.125 inch at the bottom.

When the truck is placed in a situation where the truck is required to damp out both vertical and lateral oscillations, the control coil forces increase with addition vertical motions. This causes an increased lateral force on the bolster wedge pocket side wall, thereby increasing the wear. This continuous wearing action of the wedge on the side wall causes vertical and lateral mechanical stops to form.

The three-piece truck does not have an active lateral suspension but relies entirely on the lateral shear stiffness of the load coils. Due to the wire diameter, shorter travel coils, such as the D2's and D3's, have a larger shear stiffness when compared to the longer travel coils, such as the D5's or D7's. Recent observations on trucks equipped with D7 coils, rather than D5's, on TTC's High Tonnage Loop show increased inner and outer gib wear. Gib wear appears to be directly related to the lateral shear stiffness of the load coils. If the outer gib clearance is increased again to reduce wear on the outer gib, it is likely that the hidden wear in the bolster pocket will increase.

FUTURE WORK

To quantify how truck wear affects performance, three states of truck wear will be tested for empty lateral stability (hunting), loaded twist and roll, and pitch and bounce performance. The results from these tests are anticipated to establish a relationship between truck wear and performance. These tests are currently being performed with anticipated completion date in June 1994.

Note: Contact Curt Urban (719) 584-0574 or Huimin Wu at (719) 584-0533 with questions or comments about this document.

A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, WILL BE AVAILABLE AT A LATER DATE THROUGH THE DOCUMENT DISTRIBUTION CENTER, CHICAGO TECHNICAL CENTER, 3140 SOUTH FEDERAL STREET, CHICAGO, ILLINOIS 60616. PHONE BETTY J. VAUGHAN (312) 808-5421. A REPORT LIST IS AVAILABLE UPON REQUEST.