TECHNOLOGY DIGEST
Timely Technology Transfer

"TRACK TESTS PERFORMED ON SERVICE WORN TRUCKS,"

by Curtis L. Urban and
Huimin Wu

TD 94-023

Summary

This *Technology Digest* is a continuation of the work presented in TD 94-009 "Truck Characterization Test Performed on Service Worn Trucks," June 1994.

Recent limited Chapter XI track tests were conducted on a number of service worn trucks to investigate when truck maintenance should be conducted on the standard 100-ton three-piece truck. The tests were conducted at the Transportation Test Center, Pueblo, Colorado, on three of the five service worn car sets of trucks that were tested previously for truck characterization. They were of a variable damped design and had wedge rise readings of 0, 0.5 and 1.7 inches. Due to the severity of the perturbations in the Chapter XI test sections, results showed very little difference in overall performance among the trucks tested.

Chapter XI track testing consisted of empty lateral stability (hunting), loaded pitch and bounce, twist and roll, yaw and sway and curving. The results from the hunting track test showed a 15 mph drop in performance in the responses from the best to the worst trucks tested. The results from loaded pitch and bounce, yaw and sway, and curving tests showed very little difference in the responses. The twist and roll tests showed that the best truck (simulated zero wedge rise truck) passed and all other trucks failed.

Maintenance guidelines and procedures will be recommended from the results of these tests.

Association of American Railroads
Research and Test Department
November 1994

TECHNOLOGY DIGEST
November 1994

INTRODUCTION

This research was conducted by the Association of American Railroads (AAR) at the request of the Mechanical Division Sub-Committee on Research. The research sub-committee asked the AAR to investigate 100-ton freight car performance and 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 instrumented truck to investigate the relationship between wear and performance. A combination truck was selected to allow 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 identical car sets of 100-ton variable damped truck designs with various wedge rise conditions were obtained from a member road to further the understanding of how truck performance is affected by wear. The trucks were characterized for vertical, lateral, and warp damping and stiffness parameters using the Mini-Shaker Unit located in the Transportation Test Center's Rail Dynamics Laboratory. Friction wedge rise, a widely accepted 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.

Please refer to **TD 94-009, June 1994**, for the results obtained from the truck characterization test conducted earlier this year. Only the results obtained from the track test will be presented in this *Technology Digest*.

TRACK TEST

All of the track tests were conducted with the same car body and wheel sets. Only the trucks were changed from test to test. Each of the secondary suspensions was equipped with 7-D5 outers, 6-D5 inners, and double side coils. All trucks had lubricated center bowls and roller side bearings.

Lateral Stability (Hunting) Track Test Results

Four truck conditions were tested with the following wedge rises:

1. Car Set A with 0.4 to 0.5 inch of wedge rise.
2. Car Set B with 1.5 to 1.7 inches of wedge rise.
3. Car set A was equipped with 0.5-inch shims placed under the control coils to simulate a newer truck condition.
4. Car set A friction wedges removed.

Exhibit 1 shows the results obtained from the tests. The onset speed and critical Chapter XI limits have been added to the plot for ease of interpolation.

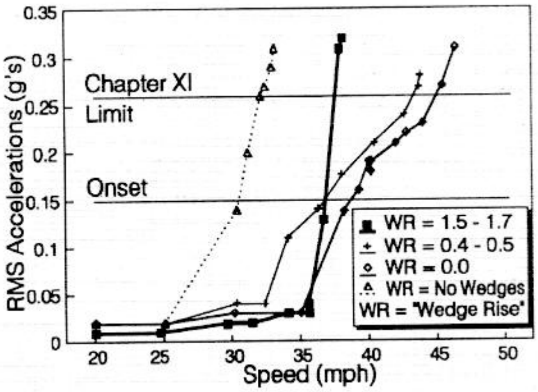

Exhibit 1. Comparison of Lateral Car Body RMS Accelerations and Wedge Rise vs Speed

Problems were encountered during the initial hunting test conducted in the "typical" hunting test section on the Railroad Test Track (RTT) station R39 to R33. This test section is constructed with staggered 39-foot, 136-pound rail sections. During the initial test, using the 1.5- to 1.7-inch wedge rise trucks, the vehicle experienced repeated wheel lifts at 30-32 mph due to the staggered joints. From theoretical calculations, the empty car effectively had zero friction damping at the 1.3-inch wedge rise condition.

The hunting tests were then conducted on a section of track with continuously welded rail, RTT section R20 to R10. A maximum speed of 45 mph was achieved with the "simulated zero wedge rise truck" before exceeding the Chapter XI car body RMS for acceleration limit of 0.26. Performance deteriorated as the wedge rise increased; i.e., from 0.5 to 1.5, and no wedges. For the "no wedge" truck condition, the maximum speed obtained prior to exceeding the Chapter XI criterion was 30 mph.

During the test, there were two distinct hunting modes observed. The car body responded with an uncontrollable yaw mode for trucks with little or no warp restraint. For trucks with a larger warp restraint, the car body response was more of a sway mode. This can be seen in the data presented in Exhibit 1. Trucks without wedges and 1.5 inches of wedge rise show a sharp change with speed. Trucks with 0.5 and 0.0 inch of wedge rise show a more gradual change in response with speed.

Pitch and Bounce Track Test Results

The Chapter XI pitch and bounce test section is constructed on the Precision Test Track (PTT) with ten 39-foot vertical sinusoidal 0.75-inch amplitude inputs. The perturbations are placed in the track in an in-phase (side by side) pattern. The test section is intended to excite the loaded vehicle in a pitch or bounce type of resonance by simulating soft or weak rail joints. The objective of the test is to ensure that the vehicle/truck combination can damp out any unwanted pitch or bounce frequencies. The results from these test are shown in Exhibit 2 and were obtained from the instrumented wheel sets installed in the lead truck of the vehicle. The Chapter XI pitch and bounce criterion of 10 percent wheel load has been added to the plot for ease of interpolation. Also added is the proposed truck performance 1.5 dynamic load factor pass/fail limit.

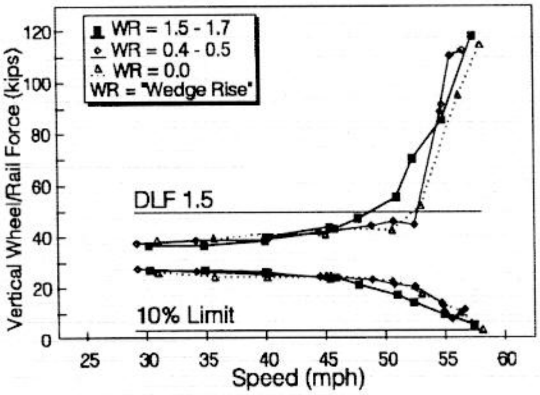

Exhibit 2. Comparison of Maximum and Minimum Vertical Wheel/Rail Forces and Wedge Rise vs Speed

As seen in Exhibit 2, from 30 to 45 mph, there is very little difference in maximum and minimum wheel load data in the responses of the trucks tested. The most dramatic difference in responses is from 45 mph to 55 mph. The responses converge at 57 mph, the maximum speed obtained during these test. All trucks converge to approximately 120 kips during the loading cycle and 3 kips on the unloading cycle. All trucks failed to meet the Chapter XI criterion of 10 percent wheel unloading for this test. Testing was halted at 57 mph due to extreme high and low vertical loads. The low vertical loads were tending to induce an unwanted hunting oscillation in the car body/truck that was deemed to be unsafe for faster operating speeds.

Not shown is the secondary suspension travel versus speed for these trucks. From the data, there is a clear trend that larger wedge rise trucks have less reserve travel when negotiating these perturbations. These trucks would generate larger suspension, wheel/rail forces when negotiating perturbations that would tend to induce spring bottoming.

Twist and Roll Track Test Results

The Chapter XI twist and roll test section is constructed on the PTT with ten 39-foot vertical sinusoidal 0.75-inch amplitude inputs, placed out of phase (staggered rail pattern). Again, the objective of the test is to ensure that the vehicle/truck combination can damp out unwanted twist and roll oscillations. The results from these test are shown in Exhibit 3. Again, the Chapter XI twist and roll pass/fail criteria have been added to the plot for ease of interpolation.

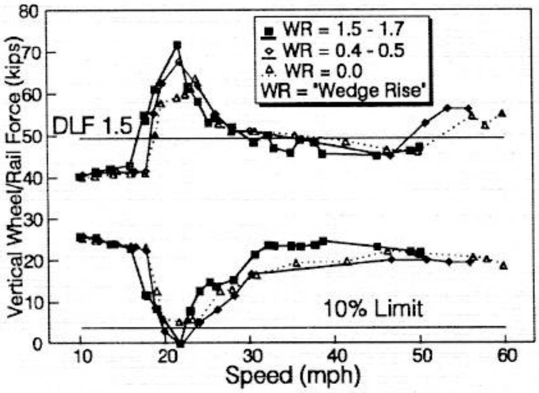

Exhibit 3. Comparison of Maximum and Minimum Vertical Wheel/Rail Forces and Wedge Rise vs Speed

From the data of minimum and maximum wheel rail forces versus speed, presented in Exhibit 3, there is again no difference in the performance of these trucks. All conditions tested failed to meet the 10 percent wheel unloading criterion for this test, except one. Only the shimmed 0.5-inch wedge rise truck simulating a 0.0-inch wedge rise condition passed.

All trucks experienced wheel lifts at 20-23 mph, except the simulated zero wedge rise condition. The simulated zero wedge rise truck passed the minimum 10-percent static wheel load criterion for Chapter XI. Not presented are the secondary suspension system displacements. The trucks with wedge rises of 0.5 inch or greater had less reserve travel than the simulated zero wedge rise truck. This again, indicates that there is less room for vertical loading for these trucks without generating larger forces due to spring bottoming.

Yaw and Sway Track Test Results

The Chapter XI yaw and sway test section is constructed on the PTT with five 39-foot lateral sinusoidal 1.25-inch amplitude inputs with 1-inch-wide gage. The test section is intended to excite the loaded vehicle in a yaw or sway response by simulating soft or weak rail joints. The results from these test are shown in Exhibit 4 and were obtained from the instrumented wheel sets installed in the lead truck of the vehicle.

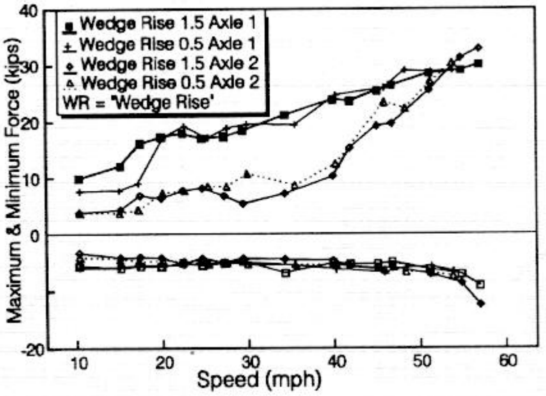

Exhibit 4. Comparison of Maximum and Minimum Lateral Wheel/Rail Forces and Wedge Rise vs Speed

The maximum and minimum lateral wheel/rail forces are presented in Exhibit 4 and indicate difference in the response of the two truck conditions tested. The tests were discontinued due to the extremely high lateral wheel/rail forces generated.

During the yaw and sway test, three distinct modes of response were observed:

> Mode 1. Speeds from 10 mph to 20-22 mph -- from observations, the wheel sets/trucks tended to steer through the perturbations. The data for axle 1 of the 0.5-inch wedge rise truck shows lower lateral forces indicating better steering up to approximately 22 mph.
>
> Mode 2. Speeds from 20-22 mph to 40 mph -- the trucks tended to warp through the test section. This was indicated by observations and displacement transducers measuring truck warp.
>
> Mode 3. Above 40 mph -- the amplitudes of the track inputs cause a lateral shift of the wheel sets thereby increasing the lateral wheel/rail forces with speed.

Curving Track Test Results

Limited curving tests were performed on the 7.5-degree curvature section of the Balloon Track. One speed, 22 mph, corresponding to 2-inch underbalance was tested for the 0.5- and 1.5-inch wedge rise conditions. The results are not presented here, but again the two trucks tested performed nearly the same.

CONCLUSIONS

From the data presented, it is clear that the Chapter XI perturbations exceed the capabilities of the friction damping system of these trucks. For the most part, the performance of these trucks are nearly identical given the nature of the inputs and that the current three-piece truck relies on friction to damp out unwanted oscillations.

The next logical step is to investigate the performance of these trucks using the computer simulation model NUCARS. We have seen that the Chapter XI inputs are too severe, and NUCARS can be used as a tool to investigate the effects of perturbation size, friction levels, wheel set profile, and wedge rise on the response of these trucks. The results from these investigations will be reported in a future *Technology Digest*.

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.