TECHNOLOGY DIGEST

Timely Technology Transfer

"IMPROVED RIDE QUALITY FOR TRANSPORTATION OF FINISHED AUTOMOBILES BY RAIL"

by Ken Rownd, Curt Urban, and Darrell Iler

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Summary

Partnerships between the railroad and automotive industries have been established to identify performance objectives for transporting finished automobiles by rail. As a result, ride quality tests have been performed at the Association of American Railroad's (AAR) Transportation Technology Center (TTC), in Pueblo, Colorado, using multi-level railcars equipped with conventional (old technology), premium, and advanced suspensions. These tests have demonstrated the capability to meet newly developed ride quality performance requirements using existing railcars.

This digest summarizes the ride quality performance of a bi-level railcar, equipped with these three truck technologies, in controlled tests at TTC.

The tests were performed in cooperation with TTX Company as part of AAR's Advanced Freight Car Truck — Design program. The goal of the program is to promote the development of innovative suspensions for freight cars based on commodity-specific requirements. Additional support has been received from a joint railroad and automotive industry group, the Quality and Maintenance of Today's Equipment.

Suggested Distribution:
- ❑ Equipment/Rolling Stock
- ❑ Research and Development
- ❑ Intermodal
- ❑ Car Department

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Research and Test Department
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INTRODUCTION AND CONCLUSIONS

The Association of American Railroads (AAR) and TTX conducted a test and analysis program to determine baseline ride quality performance for a bi-level autorack car using: (old) three-piece truck technology, a premium truck design, and the program's first advanced suspension design.

The test program demonstrated the following:

- The old technology truck does not meet ride quality requirements for lateral or vertical performance.
- The premium truck meets requirements for lateral performance but does not meet expectations for vertical performance.
- The advanced truck meets both lateral and vertical performance requirements.

The objective of the Advanced Freight Car Truck — Design program is to foster development of a new and innovative generation of freight car trucks using a performance-based design approach to replace existing three-piece trucks. A performance specification was prepared for the bi-level car system. The specification addresses safety, ride quality, and economic issues. Thirteen conceptual designs were proposed by the truck designers to meet this specification.

BACKGROUND

Nearly 70 percent of finished automobiles are transported by rail. One joint railroad and automotive industry group, the Future Distributions Systems (FDS) Task Force, investigated several alternative concepts to conventional autorack service. These alternatives were primarily focused on custom automobile racks mounted in containers (or trailers) or on totally new multilevel railcar designs.

An important product of the FDS program was the generation of a recommended practice for auto transportation titled: ***Ride Quality Performance Requirements for Motor Vehicle Shipments.*** For the first time, the railroad and automotive industries have reached agreement on how ride quality data is to be collected and analyzed as a result of this recommended practice. It describes standard methods for evaluating ride quality performance. These include controlled tests over specially constructed track anomalies, impact tests, and over-the-road tests on selected railroad properties.

ISSUES

Investment In Existing Fleet

Effective use of the existing fleet of more than 45,000 multi-level auto rack cars and associated facilities is one important issue. Multi-level service is the quickest and most cost-effective method for shipping automobiles by rail. Multi-level service will continue to be the standard for many years if ride quality performance can be improved.

Vertical Ride Performance

In past years, the automotive industry was primarily concerned with the longitudinal and lateral stability of multi-level cars. To achieve improved lateral stability, TTX recently initiated a program to replace old technology three-piece trucks with premium trucks. The automotive industry has collected over-the-road data on cars equipped with the premium truck. These tests raised concern about the vertical ride performance.

Automotive Suspensions and Restraints

The automotive industry has decided to move from the traditional chain tie-down system to a wheel chock system for restraining automobiles on rack cars. The chain system effectively locks out the automobile suspension by pulling the automobile toward the rail car deck. This makes response to railcar movement predictable, but can transmit damaging shock loads into automobiles.

Chock systems restrain automobile wheels from gross longitudinal movement but allow auto suspensions to function during transport. The chock method can reduce damage from shock loads; however, it makes response to rail car input dependent on the automobile suspension. Exhibit 1 shows an automobile restrained by a wheel chock system.

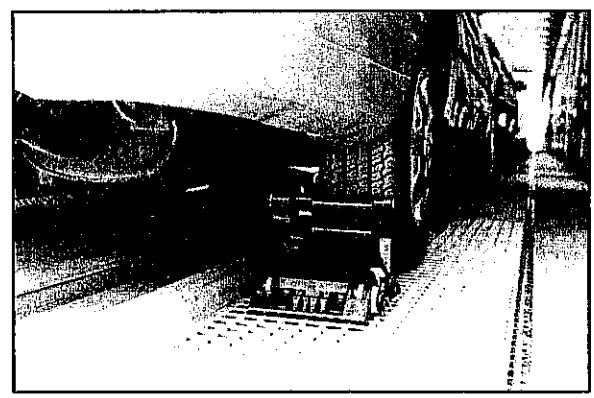

Exhibit 1. Automobile Restrained on Railcar Deck with Wheel Chock System

TRUCKS TESTED

The Old Technology Truck

This suspension serves as the baseline for all trucks tested in the Advanced Truck program. It has 33-inch wheels with 70-ton capacity sideframes and bolsters. This design has a secondary coil spring suspension with friction snubbing. The spring group consists of seven outer and three inner D-5 coils. The truck tested had constant damping and is outfitted with Miner TCC-II-60 constant contact side bearings.

The Premium Truck

The premium truck also has 70-ton capacity sideframes and bolsters. The sideframes are connected by a transom acting as a shear plate to increase warp resistance. Special bearing adapters with a rocker seat allow the sideframes to swing laterally. This lateral degree of freedom decouples the wheel set and truck motion from the car body lateral motion. The secondary suspension utilizes variable friction damping provided by wedges controlled by two No. 49427 coils. Low friction material is applied to the vertical surface of the wedges. The spring nest consists of six D7 outer coils. The truck is equipped with Miner TCC-II-60 constant contact side bearings.

The Advanced Truck

The advanced truck, shown in Exhibit 2, is a modified 70-ton design with 33-inch wheels. The truck has a leaf spring bolster that rests on a spring nest of four D-7 coil springs per side. The D-7s ride on a transom, which rests in the bottom of a modified 70-ton sideframe. The connections between the transom and the sideframes allow lateral motion. The side bearings are Miner TCC II - 35 long travel, set at 4 3/4 inches height under load. The side bearings are attached to the leaf spring bolster. Koni O2A-1374 vertical dampers are attached to the side bearing caps and sideframe.

CONTROLLED TESTS AT TTC

High Speed Stability

The high speed stability test is conducted over a 5,000-foot smooth tangent track. The criterion for success is a standard deviation of lateral autorack deck acceleration of no more than 0.13, as tested at constant speeds from 40 mph to 70 mph. While the premium and advanced suspensions met the criterion, the baseline conventional truck did not. Exhibit 3 shows the comparative performance of the premium and old technology suspensions. TTX has been replacing the old three-piece truck design with the premium truck to improve lateral ride stability.

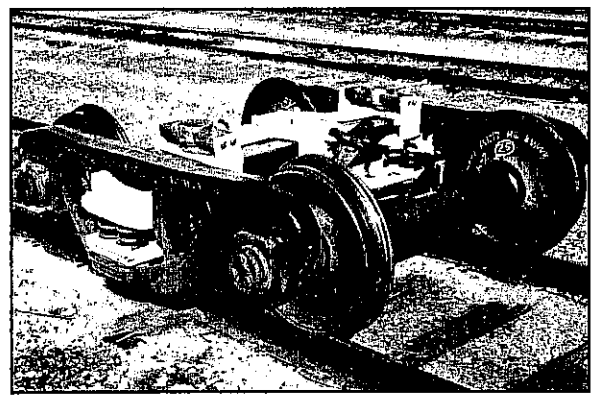

Exhibit 2. Advanced Truck Used in Ride Quality Test Program

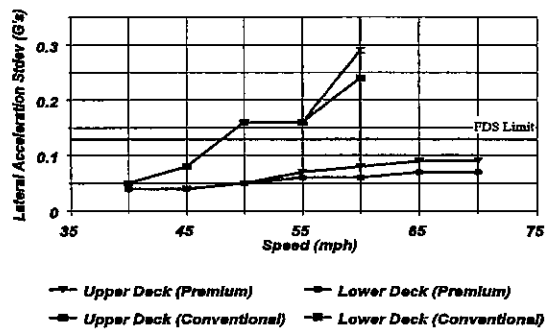

Exhibit 3. Standard Deviation of Rack Lateral Acceleration High-Speed Stability Tests with Premium and Old Technology Trucks

Pitch and Bounce

The pitch and bounce test is intended to exercise the vertical suspension. A specially constructed track with 10 vertical bumps on each rail (in phase) is used to excite the rail vehicle. Test speeds are from 40 mph to 70 mph. The criterion for success is that maximum vertical deck acceleration must be no more than 0.5 g.

Exhibit 4 shows the maximum and minimum rack acceleration for the premium and advanced trucks at each speed tested. At speeds above 55 mph, the premium truck exceeded the criterion. The automobile manufacturers have expressed concern over the vertical ride performance for this premium design. Unlike the premium truck, the

advanced truck stays within the performance criterion, indicating improved vertical suspension.

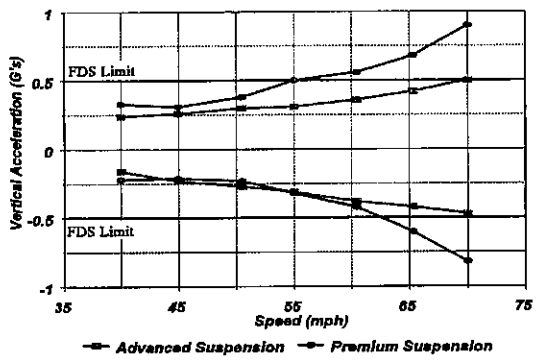

Exhibit 4. Maximum Vertical Deck Acceleration - Pitch and Bounce Premium and Advanced Suspension Tests

Pitch and Bounce Automobile Response

Exhibit 5 shows the response of a pickup and sedan to the rail car deck accelerations, as tested with the premium truck. The reaction of the automobile appears to be independent of speed above some level of rack motion. Data for the automobiles, as tested with the advanced and (old) three-piece trucks, shows the same trend. The sedan had much less response to deck motion than the pickup truck. Although there is no official criteria for automobile acceleration, this data points out the need to consider the automobile suspension when evaluating suspensions for rail cars when the wheel chock method of restraint is employed.

Twist and Roll

Twist and roll response is initiated by testing on track constructed with 10 vertical bumps (out of phase) on tangent track. Speeds tested are from 10 mph to 70 mph. The criterion for success is that maximum vertical and lateral deck acceleration must be no more than 0.5 g. While the premium and advanced truck designs met the requirements, the old technology truck did not.

Exhibit 6 shows the automobile response to lateral deck acceleration for the premium truck tests. The pickup truck had roughly twice the response as the sedan in lateral acceleration, reaching peak response 10 mph sooner.

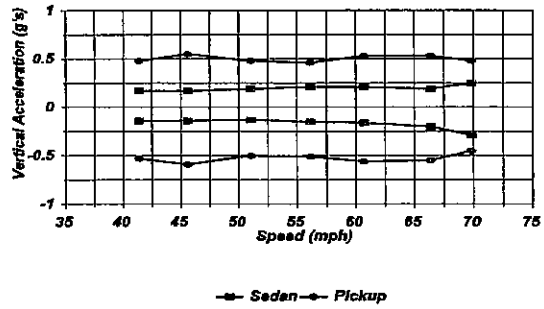

Exhibit 5. Maximum Vertical Automobile Acceleration - Pitch and Bounce During Premium Suspension Tests for Railcars

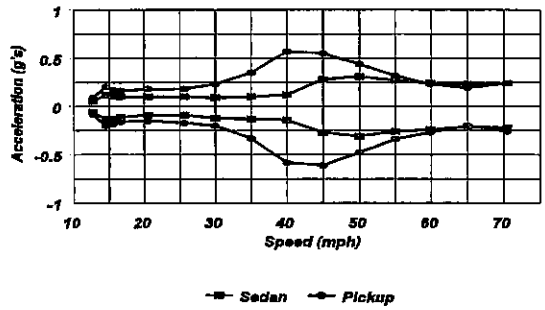

Exhibit 6. Maximum Automobile Lateral Acceleration - Twist and Roll During Premium Suspension Tests for Railcars

FOLLOW-UP WORK

The freight car trucks involved in the controlled tests will be tested in revenue service in accordance with the recommended practice to determine over-the-road ride quality performance.

ACKNOWLEDGMENT

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Contact: Ken Rownd at (719) 584-0552 with questions or comments about this document.

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