TECHNOLOGY DIGEST

Timely Technology Transfer

Improved Ride Quality for Rail Transport of Finished Automobiles

by Ken Rownd, Curt Urban, and Darrell Iler

TD 97-039

Summary

Ride-quality tests performed on multi-level railcars equipped with improved and advanced suspensions have demonstrated the capability to meet newly developed performance requirements. This digest summarizes the ride-quality performance of a bi-level railcar equipped with three advanced truck technologies in controlled tests at the Transportation Technology Center (TTC), near Pueblo, Colorado.

The tests were performed in cooperation with TTX Company as part of the Association of American Railroads' 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 Equipment working group. These partnerships between the railroad and automotive industry were formed to identify performance objectives for transporting finished automobiles by rail.

In total, 15 concepts were offered in response to solicitation for new suspensions. Twelve have been tested at TTC. Results from three truck designs were reported in TD 96-021. In 1997 work has begun to identify better-performing trucks for tri-level railcars.

Suggested Distribution:

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

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Railway Technology Department

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ed between the frame and car body. Each strut replaces the side bearing. No load is carried at the center pivot location. Longitudinal forces are transmitted to the car body through a Watts linkage. Vertical load equalization is provided by flexibility in the frame and the secondary suspension struts. Lateral stability and yaw motions of the axles are controlled by a frame-mounted shear-stiffening linkage, and by a lateral damper.

The Buckeye Steel Castings GSI-BX Truck: This is a modified baggage car truck with an H-frame structure. The secondary suspension on each side sits on an equalizer beam that transfers loads between axles and to the H-frame. The secondary suspension on each side has two coil springs and a rotary hydraulic damper connected between the H-frame and the equalizer beam. The rotary damper provides twice as much vertical damping on the upward stroke as compared to that on the downward stroke. As shown in Exhibit 2, the bolster is suspended from the H-frame by swing hangers to provide a lateral suspension.

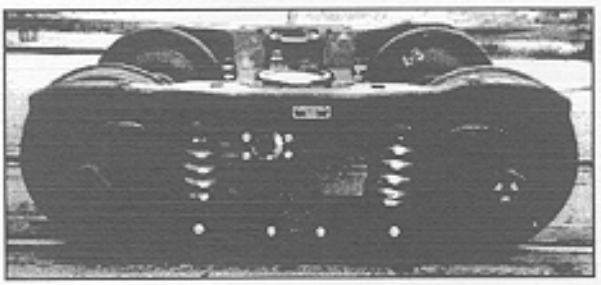

Exhibit 2. The GSI-BX Truck

The NACO Axle-Motion Truck: The axle-motion truck is adapted from the uni-truck single-axle suspension design. Two single-axle suspensions are attached in a fabricated H-frame as shown in exhibits 3 and 4. The primary suspension at each wheel is four coil springs. Two of the four springs also provide the column load for 60-degree wedges located on each side of the wheel. The primary suspension and swing hanger connection allows each axle limited longitudinal, lateral, and roll

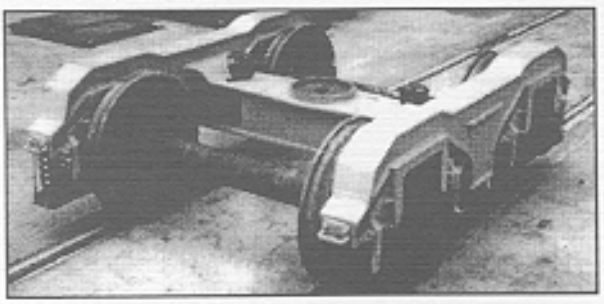

Exhibit 3. The NACO Axle Motion Truck

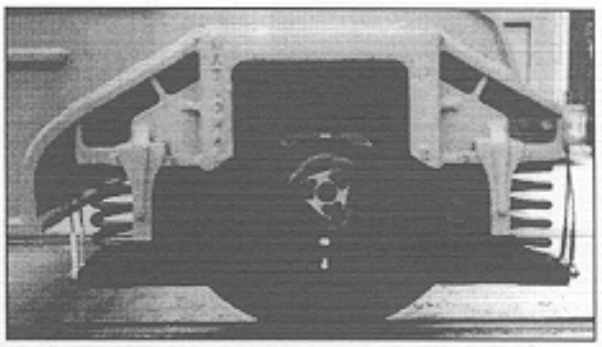

Exhibit 4. Close-up of Single-Axle and Suspension System on the NACO Axle-Motion Truck

movement. This feature provides steering capability and lateral decoupling for high-speed stability.

CONTROLLED TESTS AT TTC

High-Speed Stability

The high-speed stability test is conducted over a smooth, 5,000-foot, tangent track. The criterion for success is a standard deviation of lateral auto-rack deck acceleration of no more than 0.13 g, as tested at constant speeds from 40 mph to 70 mph. All three trucks met high-speed stability criteria as shown in Exhibit 5.

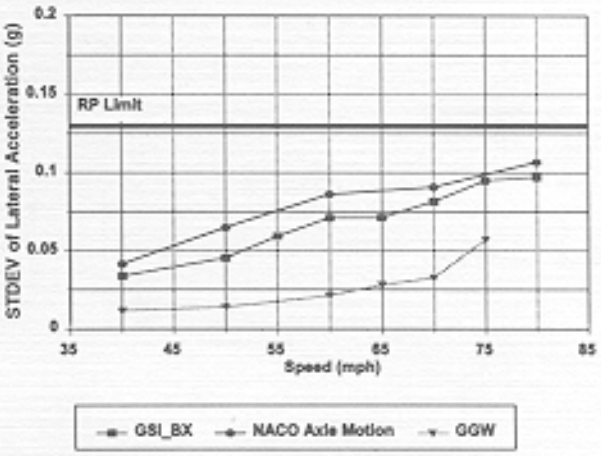

Exhibit 5. Lateral Ride-Quality Performance during High-Speed Stability Tests

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. Specified test speeds are from 40 mph to 70 mph. All three trucks were tested to 80 mph to determine resonant speed. The criterion for success is that maximum vertical deck acceleration must be no more than 0.5 g at speeds to 70 mph. All three trucks met pitch and bounce criteria as shown in Exhibit 6.

INTRODUCTION AND CONCLUSIONS

The Association of American Railroads (AAR) and TTX conducted a test and analysis program to determine ride-quality performance for advanced and premium truck designs. The test program concluded:

- Four advanced trucks have met all ride-quality requirements in controlled tests. One of these, the TI-7R, was reported in TD 96-021. Results from the other three will be reported in this TD.
- Two advanced trucks have not met ride-quality performance standards. One additional design will tested in 1997.
- Of the six versions of today's premium trucks tested, two of these met lateral performance requirements, while demonstrating improved vertical performance.

The objective of the Advanced Freight Car Truck-Design program is to foster development of new freight car trucks using a performance-based design approach. A performance specification was prepared for the bi-level car system. The specification addresses safety, ride quality, and economic issues. Fifteen concepts were offered in response to a solicitation for new suspensions.

BACKGROUND

Nearly 70 percent of finished automobiles are transported by rail. The railroad and automobile industry have generated a recommended practice (RP 803-96) for automobile transportation titled: "Ride Quality Performance Requirements for Motor Vehicle Shipments." For the first time, agreement on how ride-quality data is to be collected and analyzed was achieved. The RP describes standard methods for evaluating ride-quality. These include controlled tests over specially constructed track anomalies, impact tests, and over-the-road tests on selected railroad routes.

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 key issue. Currently, 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 ride quality of the multi-level cars. To achieve improved lateral performance, 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 a premium truck. These tests identified the need to improve 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 a rack car. The chain system effectively locks out the automobile suspension by pulling the automobile toward the rail car. This makes response to railcar movement predictable, but can transmit damaging shock loads into the automobile. Chock systems restrain automobile wheels from gross longitudinal movement but allow the automobile suspension to function during transport. The chock method can reduce damage from shock loads; however, response to railcar input becomes dependent on the automobile suspension. As documented in TD 97-038, the live load resulting from the chock method also changes the response of the railcar system to track and operating variables.

ADVANCED TRUCKS TESTED

All advanced trucks tested in 1996 utilized TCC II-60 constant-contact side bearings with the exception of the GG&W design. The trucks were designed for a 225,000-pound capacity but are sprung for a maximum weight on rail of 153,000 pounds.

The GG&W Truck: The GG&W truck shown in Exhibit 1 is a passive steering design. The primary suspension is provided through Metacone elastomer units between the axle and frame. The secondary suspension is mounted in two load-bearing struts each consisting of one 23½-inch coil spring and a hydraulic damper locat-

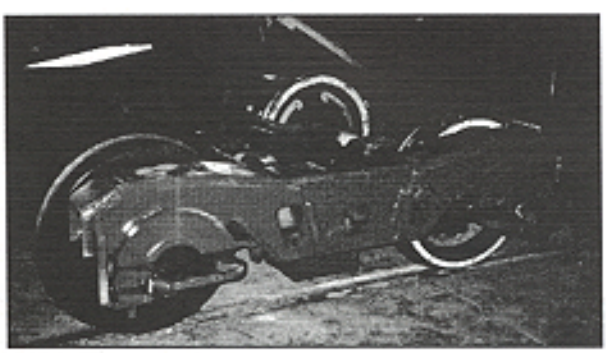

Exhibit 1. The GG&W Truck

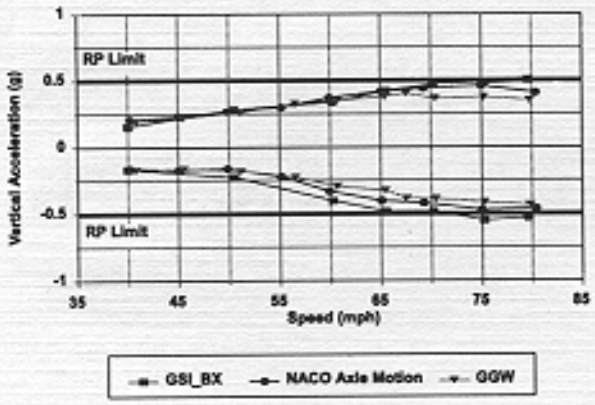

Exhibit 6. Vertical Ride-Quality Performance during Pitch and Bounce Tests

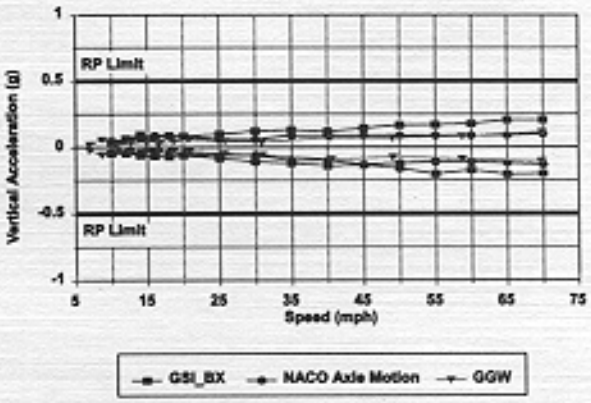

Exhibit 8. Vertical Ride-Quality Performance during Twist and Roll Tests

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 criteria for success is that maximum vertical and lateral deck acceleration must be no more than 0.5 g. All three trucks met twist and roll criteria as shown in Exhibit 7 (lateral) and Exhibit 8 (vertical).

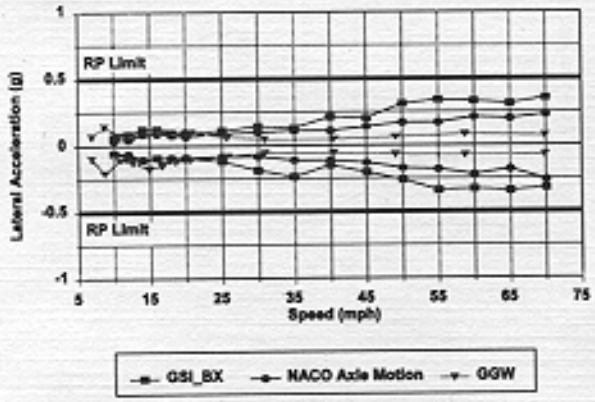

Exhibit 7. Lateral Ride-Quality Performance during Twist and Roll Tests

ASSOCIATED WORK

The three advanced trucks presented in this report are candidates for testing in 6,000-mile railroad service to complete the RP requirements. Work being performed on multi-level auto-racks in 1997 includes:

- Two bi-level car premium trucks and a baseline tri-level car truck are being tested in 6,000-mile railroad service in July.
- Shaker testing of a loaded tri-level auto-rack car was conducted in May to document effect of live load on system performance and to develop an engineering model of the tri-level car.
- Advanced truck designs for tri-level service using the tri-level model are being solicited.
- The baseline tri-level truck and an advanced tri-level truck have been tested at TTC.
- End-of-car cushioning improvements are being modeled to estimate longitudinal ride-quality performance.

ACKNOWLEDGMENT

The authors acknowledge the TTX company and members of the automotive and railroad industry for their support in funding and promoting the concept of advanced suspensions for railcars used in automobile transport.

Note: Contact Ken Rownd at (719) 584-0552 with questions or comments about this document.
E-mail: ken_rownd@aar.com