TECHNOLOGY DIGEST

Timely Technology Transfer — 98-032

ADVANCED SUSPENSIONS MEET PERFORMANCE STANDARDS FOR BI-LEVEL AUTO-RACK CARS

by Ken Rownd and Darrell Iler

Summary

Tests conducted by Transportation Technology Center, Inc., have demonstrated that advanced suspension designs can be used in existing bi-level auto racks to meet ride-quality standards for transporting finished automobiles.

Controlled tests at the Federal Railroad Administration's Transportation Technology Center are used to screen suspension designs that may meet auto manufacturers' expectations in railroad service. These tests demonstrated that prototype suspensions from Buckeye Steel Castings and NACO Technologies meet ride-quality performance criteria jointly determined by the automobile and railroad industries in 1996. Further tests also indicate that a modified GG&W Technologies truck design will meet performance requirements. Earlier tests demonstrated that the Krupp TI-7R also met performance criteria.

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 criteria. Additional support has been received from a joint railroad and automotive industry group, the Quality and Maintenance of Equipment. Partnerships such as this one between the railroad and automotive industries were established to identify performance objectives for transporting finished automobiles by rail.

Suggested Distribution:

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

Work performed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

December 1998©
Revised January 2002

INTRODUCTION AND CONCLUSIONS

Tests in railroad service show that ride quality during transportation of finished automobiles can be improved with new freight-car suspensions. These tests were performed in cooperation with TTX Company as part of the Advanced Freight Car Truck Design program. Manufacturers have identified enhanced ride performance as key to meeting the following goals:

- Error-free transportation
- Eliminate rail ride quality as an automobile-design consideration

A recommended practice published in 1996 (RP803-96) describes ride-quality expectations for railcars involved in transportation of finished automobiles. The RP describes criteria for controlled testing and a 5,500-mile, railroad-service trial.

Using the methods described in the RP, 15 suspension designs were tested in the same bi-level auto rack at the Federal Railroad Administration's Transportation Technology Center (TTC). Five designs met controlled-test criteria. One truck, the Krupp TI-7R was tested in railroad service in 1996. It met RP criteria as described in TD96-022. A second version of the Krupp truck met controlled-test criteria but was not tested in railroad service. This TD describes the other three successful candidates as tested together in railroad service.

The railroad-service test program demonstrated the following:

- Performance improvements measured in controlled tests were confirmed by improvements measured in railroad service.
- The NACO Axle Motion truck and the Buckeye GSI-BX trucks met RP criteria.
- The GG&W Technologies truck met all criteria except the maximum lateral acceleration criterion. The reason for the GG&W criterion exception was identified in tests at TTC and a fix was developed to improve performance.
- Performance for all three trucks, and for the Krupp truck tested in 1996, was superior to that measured for baseline old-technology suspensions.
- Auto manufacturers' expectations can be met with the existing fleet of 48,000 autorack cars.

BACKGROUND

Partnerships between the railroad and automotive industries have been established to identify performance objectives for transporting finished automobiles by rail. These objectives are expressed as acceleration performance criteria measured in tests defined in a recommended practice titled: "Ride Quality Performance Criteria for Motor Vehicle Shipments" (RP803-96).

The recommended practice specifies standard test and analysis cases for evaluating ride-quality performance. Meeting the RP calls for controlled tests over specially constructed track anomalies, and over-the-road tests on selected railroad property. Controlled tests are used to identify weaknesses in design and to promote design development. Over-the-road tests document in-service performance for designs which meet controlled-test criteria.

TRUCKS TESTED

The GG&W Technologies truck: The GG&W truck is a passive-steering design based upon the patented Scheffel frame-mounted shear-stiffener concept. The truck is a bolsterless design. Primary suspension is provided through Metacone elastomer units between the axle and frame. Secondary suspension is mounted in two load-bearing struts each consisting of one 23.5-inch coil spring and a hydraulic damper located 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 by secondary suspension struts. Lateral stability and yaw motions of the axles are controlled by a frame-mounted shear-stiffener linkage and by lateral stops.

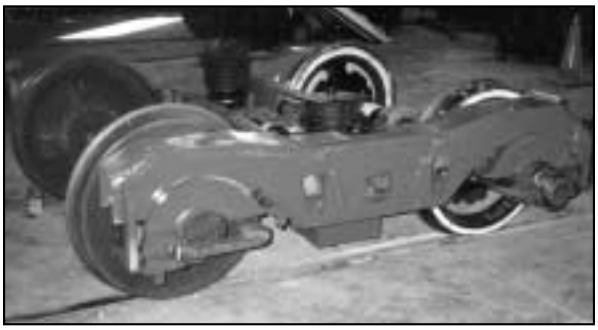

Exhibit 1. GG&W Truck for Bi-Level Auto Rack

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 rests 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 3, the bolster is suspended from the H-frame by swing hangers to provide a lateral suspension.

Exhibit 2. Buckeye Steel Castings 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. 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 axle box. The primary suspension and swing hanger connection allows each axle limited longitudinal, lateral, and roll movement. This feature provides steering capability and lateral decoupling for high-speed stability.

Exhibit 3. The NACO Axle-Motion Truck

CONTROLLED RIDE-QUALITY TESTING

Controlled tests are intended to screen potential designs before introduction into railroad service. Tests were performed at the TTC to document ride-quality and safety performance by exciting the rail-car rigid body modes of pitch, bounce, twist, and roll. In addition, curving and high-speed stability performance are tested. As documented in TD97-039, the three trucks addressed in this report met controlled-test criteria.

RAILROAD SERVICE RIDE-QUALITY TESTING

In addition to controlled test criteria, the recommended practice describes an over-the-road test which measures vertical, lateral, and longitudinal acceleration at each deck. The test route is: Newark, New Jersey, to Chicago, from Chicago to Milpitas, California, and finally from Los Angeles back to Chicago. The criteria for success is the number of occurrences at a predetermined level for each acceleration measurement. In the vertical plane, one occurrence greater than 1.0 g or 100 occurrences greater than 0.50 g per thousand miles would exceed the criteria. In the lateral plane, one occurrence greater than 0.75 g or 100 occurrences greater than 0.35 g per thousand miles would exceed the criteria.

Over-the-road data can be affected by local factors such as train handling, performance of adjacent cars, weather, special track (e.g. switches), and train speed. While evaluating the three suspensions, test variations were minimized by coupling three similar auto racks.

Lateral Performance in Railroad Service

Lateral performance criteria were met for the bi-level racks equipped with the NACO and GSI-BX suspensions. Lateral performance criterion for events per 1,000 miles was also met by the GG&W truck, however nine events exceeded the maximum lateral acceleration limit during the 5,500-mile trip. A fix for this problem is discussed below.

Vertical Performance in Railroad Service

Vertical performance has been the most difficult criterion for trucks to meet at TTC and in railroad service. Exhibit 4 lists the vertical performance for the three segments of the 5,578-mile trip. All three suspensions met criteria.

Exhibit 4 compares the controlled-test performance for a premium truck, as discussed in TD98014, and these three advanced trucks in pitch and bounce. RP controlled-test criterion is acceleration less than 0.5g at speeds up to 70 mph. Exhibit 5 shows the same trucks as tested from Chicago to

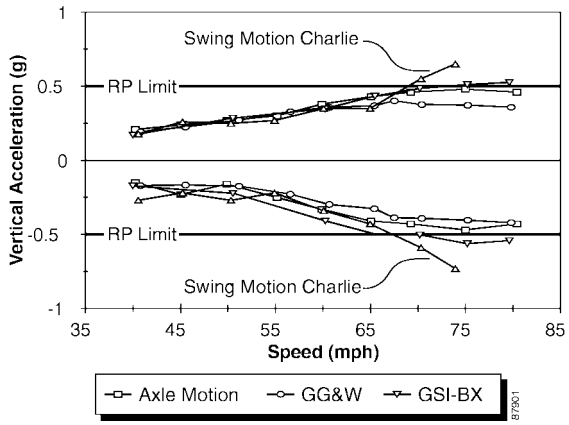

Exhibit 4. Comparison of Controlled-Test Performance for One Premium and Three Advanced Trucks

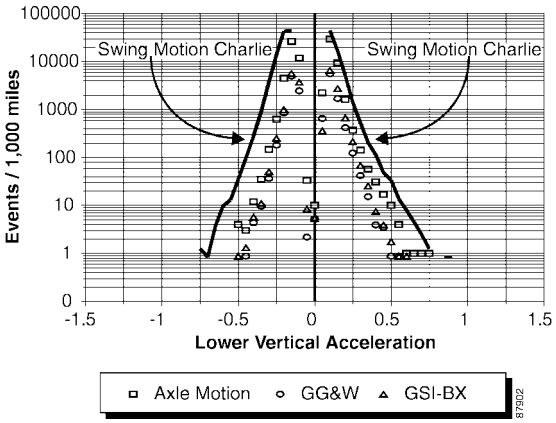

Exhibit 5. Revenue-Service Test Performance for One Premium and Three Advanced Trucks

Milpitas, California. This indicates that ride-quality improvements measured in controlled tests result in improvements in railroad service. TD 98-014 documented improvements made to the premium truck.

GG&W LATERAL PERFORMANCE

Lateral performance for all three trucks was excellent, however the GG&W truck exceeded the maximum acceleration criteria nine times during the 5,500-mile trip. A special test was conducted on the yaw-and-sway track at TTC to investigate this performance. Time history data from the railroad-service test matches the yaw and sway performance at TTC. A yaw-and-sway test is not part of RP803-96.

Exhibit 6 shows the nine maximum acceleration events measured in railroad service, the maximum acceleration measured at TTC in yaw and sway, and the maximum acceleration measured after the lateral suspension was modified. It is likely that the reduced acceleration in yaw and sway would indicate good performance in railroad service. GG&W is working to incorporate the fix into the basic design.

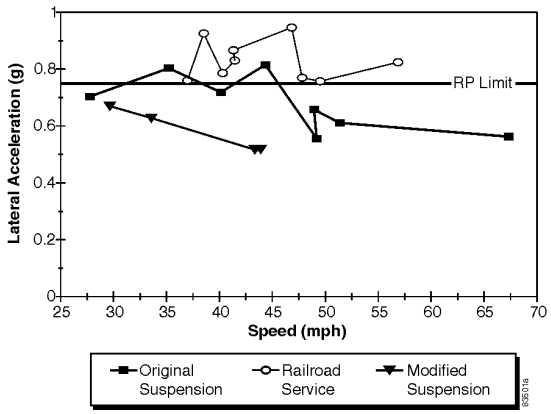

Exhibit 6: Comparison of Maximum Laterall Acceleration Events — Railroad Service and Yaw-and-Sway Test

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 transportation. This completes the test portion of the industry-funded program to promote new suspensions for bi-level auto racks. In 1999, TTX and AAR propose to monitor a limited number of the successful trucks in railroad service to document durability.

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

E-mail: **ken_rownd@ttci.aar.com**
darrell_iler@ttci.aar.com

Web site: **www.ttci.aar.com**

A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE, MD, 21279-0780.