TECHOLOGY DIGEST

Timely Technology Transfer — 98-014

USE OF MODIFIED SUSPENSIONS TO IMPROVE RIDE QUALITY IN BI-LEVEL AUTO-RACKS

by Ken Rownd, Darrell Iler, and Curt Urban

Summary

Tests conducted by the Transportation Technology Center, Inc., have demonstrated that multi-level railcars can meet newly developed ride-quality performance requirements for transporting finished automobiles. Tests included multi-level railcars equipped with old-technology, premium, and advanced suspensions.

This digest summarizes the ride-quality performance of bi-level auto-rack cars equipped with the NACO Swing Motion premium truck. Controlled testing at the Federal Railroad Administration's Transportation Technology Center (TTC) and in railroad service demonstrated that modifications to the NACO suspension result in improved vertical ride quality for the transportation of finished automobiles. Both versions of this truck were tested at TTC and in railroad service.

Before automobile manufacturers defined new requirements for ride quality, the NACO Swing Motion truck was applied to several thousand bi-level auto-rack cars to improve high-speed stability performance. However, this application did not meet automobile manufacturers' goals for vertical ride-quality performance.

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 this 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. Partnerships between the railroad and automotive industries identified performance objectives for transporting finished automobiles.

Suggested Distribution:
- ❑ Car Department
- ❑ Research & Development
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- ❑ Intermodal

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

The Association of American Railroads (AAR) recently performed tests in cooperation with TTX Company, showing that vertical ride quality can be improved by introducing minor changes to commonly used freight-car suspensions. Auto manufacturers have identified enhanced vertical ride performance as key for this fleet. The tests were carried out as part of the AAR's Advanced Freight Car Truck Design program.

A recommended practice published in 1996 (RP803-96) describes ride-quality expectations for railcars used to transport finished automobiles. The RP describes requirements for controlled testing and over-the-road testing in railroad service.

Using the methods described in the RP, a standard Swing Motion truck (designated "Bravo") and a modified Swing Motion truck (designated "Charlie") were tested in the same bi-level auto-rack car at the Federal Railroad Administration's Transportation Technology Center. As a result of the improvements in vertical ride quality measured in the controlled tests, the same trucks were tested together in railroad service.

The test program demonstrated the following:

- Performance improvements measured in controlled tests were confirmed by improvements measured in railroad service.
- The Swing Motion Charlie truck reduced vertical acceleration events by 50 percent in railroad service as compared to Swing Motion Bravo.
- Controlled test maximum acceleration performance was reduced at all speeds for Swing Motion Charlie. Swing Motion Bravo exceeded controlled vertical test criteria at 60 mph while Swing Motion Charlie exceeded at 70 mph.
- Swing Motion Charlie performance was within 20 percent of meeting ride-quality criteria.
- Lateral performance criteria were met by both Charlie and Bravo Swing Motion truck types.
- Attempting to improve the vertical performance of Charlie by increasing the friction damping resulted in unacceptable high-speed stability performance.

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 entitled: "Ride Quality Performance Requirements for Motor Vehicle Shipments" (RP803-96).

The recommended practice specifies standard test and analysis cases for evaluating ride-quality performance. It also prescribes methods for data collection and analysis. Requirements include controlled tests over specially constructed track anomalies, impact tests, and over-the-road tests on selected railroad property. The controlled tests are used to identify weaknesses in design and to promote design development. The over-the-road tests document in-service performance for designs which meet controlled-test requirements.

Improvements to the Swing Motion vertical performance was made possible when TTX lowered the maximum spring capacity and maximum weight on rail for bi-level auto-rack cars. This action was taken following a study of maximum automobile loading on bi-level cars. The new guidelines enabled NACO to change the suspension to provide a softer vertical ride.

Although the Swing Motion Charlie does not fully meet the vertical ride-quality criteria, improvements to existing equipment can change fleet performance sooner than improvements made by phasing in new suspension systems.

TRUCKS TESTED

The NACO Swing Motion Bravo Truck

The Swing Motion truck used in ride-quality tests has 70-ton design (220,000 pound weight on rail for two trucks) sideframes and bolsters, as shown in Exhibit 1. 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 lateral motion of the car body. The secondary vertical 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.

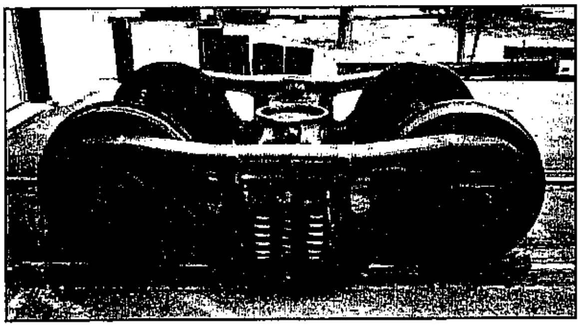

Exhibit 1. NACO Swing Motion Truck for Bi-Level Auto-Rack Railcars

The NACO Swing Motion Charlie Truck

The Charlie version of this truck has four D7 outer coils per side. The maximum capacity of the bi-level car has been redefined by TTX as 153,000 pounds with a dynamic load factor of 1.45. A further test series was conducted using steel friction wedges (designated Iron Charlie).

CONTROLLED TESTS AT TTC PER RP803-96

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 auto-rack deck acceleration of no more than 0.13, as tested at constant speeds from 40 mph to 70 mph. The Bravo and Charlie versions met this criteria. In an attempt to improve vertical performance in the Pitch and Bounce tests, the Charlie truck was further modified with iron friction shoes (designated Iron Charlie). The change to iron shoes resulted in unacceptable high-speed stability performance as shown in Exhibit 2.

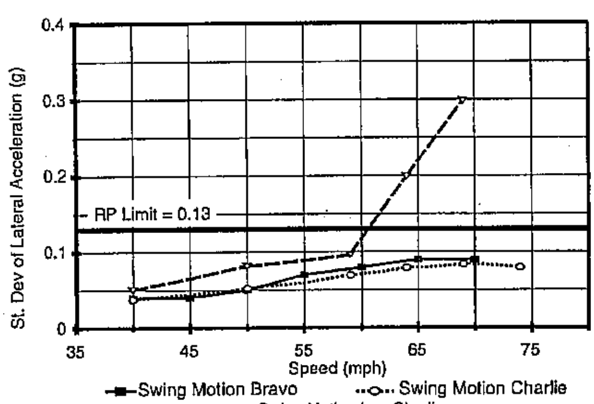

Exhibit 2. Comparison of Lateral Acceleration in High-Speed Stability Tests, Swing Motion Bravo, Charlie, and Iron Charlie Truck Types

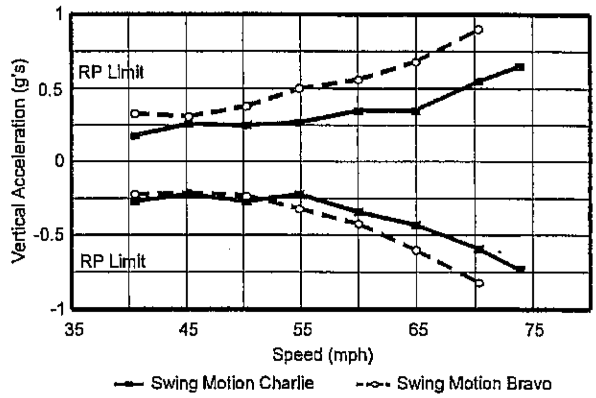

Exhibit 3. Vertical Acceleration Response in Pitch and Bounce, Swing Motion Charlie and Bravo Trucks

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 3 shows the maximum and minimum rack acceleration for the Swing Motion Bravo and Charlie trucks at each speed tested. The Charlie truck shows significant improvement at all speeds. At speeds above 55 mph, the Bravo truck exceeded the RP criterion. At 70 mph the Charlie truck exceeded criterion. Automobile manufacturers have expressed concern over the vertical ride performance for the Bravo configuration.

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. Both Swing Motion versions met criteria in this test.

OVER-THE-ROAD RIDE-QUALITY TESTING

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

* EVENTS / 1,000 MILES	SWING MOTION BI-LEVEL		
	Charlie 97	Bravo 97	Bravo 96
Newark - Chicago			
Deck 1 Events > 0.5*	5	18	22
Deck 1 Events > 1.0	0	0	0
Deck 2 Events > 0.5*	6	26	85
Deck 2 Events > 1.0	0	1	0
Chicago - Milpitas			
Deck 1 Events > 0.5*	91	202	104
Deck 1 Events > 1.0	0	2	2
Deck 2 Events > 0.5*	126	229	259
Deck 2 Events > 1.0	0	3	5
Los Angeles - Chicago			
Deck 1 Events > 0.5*	5	N/A	4
Deck 1 Events > 1.0	0	N/A	0
Deck 2 Events > 0.5*	25	N/A	25
Deck 2 Events > 1.0	0	N/A	2

Exhibit 4. Vertical Ride Quality Performance Compared to Criteria, Swing Motion Bravo and Charlie Truck Types

Over-the-road data can be dominated by local factors such as train handling, performance of adjacent cars, weather, special track (switches etc.), and train speed. To eliminate trip-to-trip variations, the Bravo and Charlie suspensions were tested together in identical auto-rack cars. Lateral performance met criteria for both versions and is not displayed here.

VERTICAL PERFORMANCE IN RAILROAD SERVICE

Exhibits 4 lists the vertical performance for the three legs of the 5,578-mile trip. Due to a data loss in the final segment for the Bravo equipment, data from a 1996 Bravo test is included.

The Charlie version met criteria for two of the three trip segments. In the middle segment the Charlie version exceeded the counts above the 0.5 g criterion while meeting the maximum acceleration criterion. The middle segment has higher speeds as shown in Exhibit 5.

The Bravo version did not meet criteria for any segment. Two of the Bravo segments met the counts above the 0.5 g criterion, however the maximum acceleration criterion was exceeded.

The middle segment vertical performance of the Bravo and Charlie truck types is shown in Exhibit 6

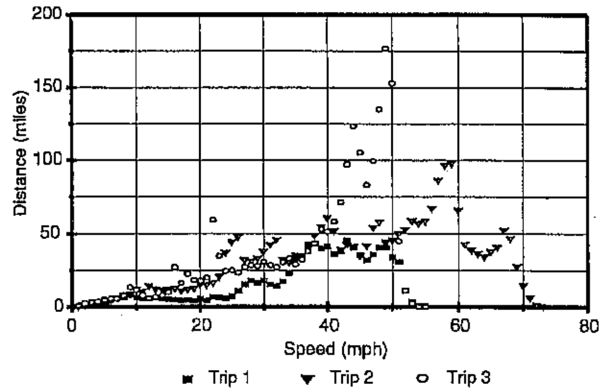

Exhibit 5. Comparison of Time at Speed for the Three Trip Segments

(upper deck). The number of vertical events reduced when comparing Charlie to Bravo versions.

ACKNOWLEDGMENT

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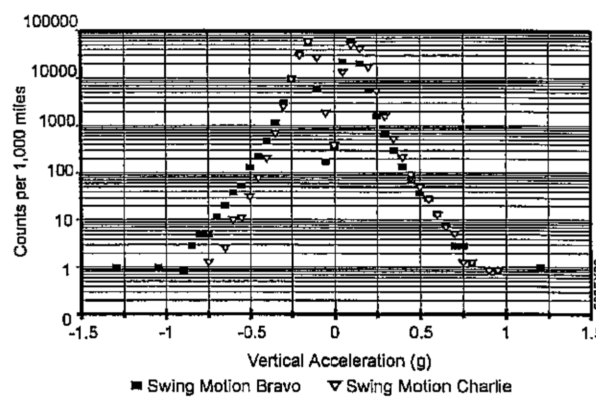

Exhibit 6: Vertical Acceleration Events, Chicago to Milpitas, Swing Motion Bravo and Charlie Truck Types

Note: Contact Ken Rownd at (719) 584-0552 or Darrell Iler at (719) 584-0546 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

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