TECHNOLOGY DIGEST

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# IMPROVED RIDE-QUALITY FOR TRANSPORTATION OF FINISHED AUTOS BY TRI-LEVEL AUTORACK

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**Summary**

Recent tests at the Federal Railroad Administration's Transportation Technology Center near Pueblo, Colorado, have demonstrated the capability of meeting newly developed ride-quality performance requirements using existing multi-level railcars equipped with improved and advanced suspensions. This digest summarizes controlled-test ride-quality performance of a tri-level railcar equipped with three truck designs. These three designs represent old-technology three-piece trucks, a premium truck used to replace the old design, and an advanced design that meets new ride-quality requirements.

These tests were performed by Transportation Technology Center, Inc., in cooperation with TTX Company as part of the Association of American Railroad's Advanced Freight Car Truck Design program. The goal of the program is to develop innovative suspensions for freight cars based on commodity-specific requirements. Additional support has been received from the Quality and Maintenance of Equipment group, one of several partnerships established between the railroad and automotive industry to define performance objectives for transporting finished automobiles by rail.

The program to implement new truck designs for bi-level autorack railcars was documented in Technology Digests 96-021, 96-022, 97-039, and 98-014. Five of the bi-level designs tested met the new ride-quality criteria.

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Work performed by TTCI Transportation Technology Center, Inc.
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## INTRODUCTION AND CONCLUSIONS

Recent tests have demonstrated the capability of meeting newly developed ride-quality performance requirements using existing multi-level railcars equipped with improved and advanced suspensions. The current multi-level fleet consists of more than 45,000 autorack freight cars. This fleet is primarily composed of standard-deck bi-level cars and low-deck tri-level cars. The tri-level fleet employs both D4 and D5 truck-suspension designs.

Transportation Technology Center, Inc., and TTX conducted a program of testing and analysis to determine ride-quality performance for a variety of autorack truck designs. Both the D4 and D5 tri-level cars are available for suspension evaluation. The D4 suspension is a more challenging design case due to space constraints. This TD will focus on three D4 truck designs. The test program demonstrated:

- The Krupp TI-7R advanced truck met controlled-test ride-quality requirements in a D4 tri-level autorack.
- A second version of the Krupp truck met requirements in a D5 tri-level.
- The NACO D4 Swing Motion did not meet the high-speed stability criterion or vertical ride-quality requirements.
- The NACO D5 Swing Motion met the high-speed stability criterion, but did not meet vertical ride-quality requirements.
- The baseline machine center three-piece truck did not meet any of the ride-quality criteria.
- The baseline truck did not meet ride-quality requirements in a 5,500-mile railroad-service test.

The objective of the Advanced Freight Car Truck Design program is to foster the development of new trucks using a performance-based design approach. A performance specification was used to solicit new truck designs for multi-level railcars. The specification addresses safety and ride-quality.

## BACKGROUND

Nearly 70 percent of finished automobiles are transported by rail. A recommended practice describing ride-quality requirements for the transportation of finished automobiles has been developed by a joint railroad and automobile industry working group. This document, RP 803-96, "Ride Quality Performance Requirements for Motor Vehicle Shipments," sets guidelines for testing and evaluating ride-quality performance. The process includes controlled tests over specially constructed track anomalies, and over-the-road tests on selected routes.

## ISSUES

- **Investment in existing fleet:** Multi-level service likely will continue to be the standard for many years if ride-quality performance can be improved. Effective use of the existing fleet of more than 45,000 multi-level autorack cars and associated facilities is an important issue. Multi-level rail service is the quickest and most cost-effective method for shipping automobiles.
- **Automotive Suspensions and Restraints:** The automotive industry has moved from the traditional chain tie-down system to a wheel-chock system for restraining automobiles on a rack car. The chock system allows the automobile to move freely on its own suspension. Improved ride quality is therefore critical to damage-free transportation of automobiles. This has focused the need for improved railcar suspensions.
- **Vertical Ride Performance:** The customer has identified new requirements for vertical and lateral ride quality. Lateral ride quality has been resolved with the premium trucks applied to the fleet. Advanced trucks are being evaluated for improved vertical and lateral ride quality.

## ADVANCED PROJECT TRUCKS TESTED

### Baseline Three-Piece Trucks

This suspension serves as the baseline in the Advanced Truck tri-level program. It has 28-inch wheels with 70-ton capacity side frames and bolsters. This design has a secondary coil-spring suspension with friction snubbing. The spring group consists of five outer and five inner D4 coils. The baseline truck had constant damping in the secondary suspension controlled by two each No. 1670 (outer) and No. 3222 (inner) coils per side. It is equipped with Stucki 656 CRH constant-contact side bearings and RFE18 friction shoes. This truck has 61-inch axle spacing. The

baseline trucks are referred to as "machine center" trucks. This indicates that machining work has been performed on the original castings to improve mating surfaces and dimensional tolerances.

### The Premium Truck

The premium truck also has 70-ton capacity side frames and bolsters. The side frames are connected by a transom acting as a shear plate to increase warp resistance. Special bearing adapters with a rocker seat allow the side frames to swing laterally. This lateral degree of freedom de-couples 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 outer and inner No. 52064 coils per side. Low-friction material is applied to the vertical surface of the wedges. The secondary spring nest consists of five D4 outer coils and two D4 inner coils. The truck is equipped with Stucki 656 CRH constant-contact side bearings. Axle spacing is 63 inches.

### The Advanced Truck

The advanced truck, shown in Exhibit 1, is a modified 70-ton design with 28-inch wheels. The truck has a leaf-spring bolster that rests on a spring nest of five outer and five inner Krupp coil springs per side. The coils ride on a transom, which rests in the bottom of a conventional 70-ton side frame. The connections between the transom and the side frames act to square the truck. The side bearings are Miner TCC II-80S long travel, set at 4.75 inches height under load. The side bearings are attached to a casting mounted to the leaf-spring bolster. Some damping occurs as the leaf springs deflect. In addition, constant spring-loaded friction damping is applied (through a low-friction surface) as the coil springs deflect. This truck can be used with 61- or 63-inch side frames, and it will fit all D4 autorack cars.

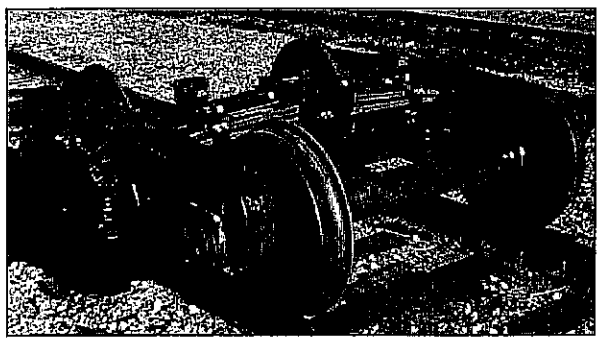

**Exhibit 1. The Krupp TI-7R Advanced Truck**

### CONTROLLED TESTS AT TTC

The bi-level experience has shown that improved performance in controlled tests correlates to significantly better performance in railroad service.

### 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 g, as tested at constant speeds from 40 mph to 70 mph. Although not required by the RP, the advanced and premium trucks were tested to 80 mph to document stability.

The advanced suspension met the criterion. The baseline truck exceeded criterion at 45 mph. The premium truck had better stability than the baseline but exceeded criterion at 65 mph. Exhibit 2 shows the comparative performance. TTX has been replacing the old three-piece truck design with the premium truck to improve lateral ride stability.

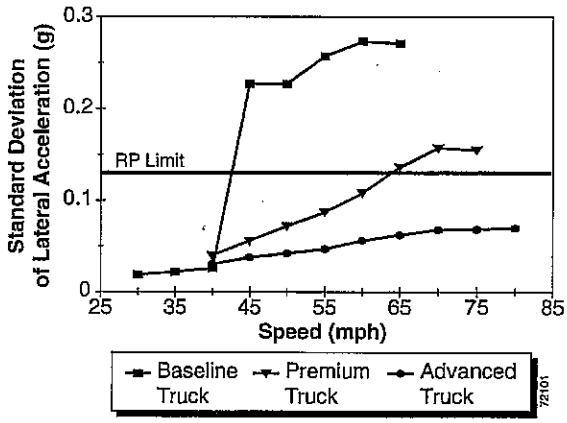


**Exhibit 2. Lateral Acceleration Performance in High-Speed Stability Testing**

### 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. The advanced truck was tested to 80 mph to document performance.

Exhibit 3 shows the maximum and minimum rack acceleration for each truck at each speed tested. At speeds above 60 mph the baseline truck exceeded criterion. At speeds above 55 mph the premium truck exceeded the criterion. 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. There will be an effort to improve the vertical performance of the premium truck.

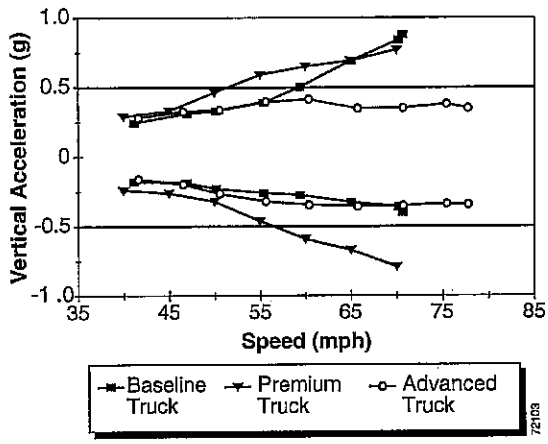


**Exhibit 3. Vertical Acceleration Performance in Pitch and Bounce Testing**

### 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. The baseline truck exceeded twist and roll lateral and vertical criteria at 60 mph. The premium and advanced trucks met criteria.

### Railroad-Service Testing

RP 803-96 requires a 5,500-mile railroad-service test. The baseline truck in a tri-level autorack was tested in 1997, along with two bi-level autorack cars. The criteria for success is as follows:

- Vertical acceleration — No events greater than 1.0 g; less than 100 events per 1,000 miles greater than 0.5 g
- Lateral Acceleration — No events greater than 0.75 g; less than 100 events per 1,000 miles greater than 0.35 g

The baseline truck did not meet vertical over-the-road criteria in this test. This performance will be compared to railroad-service performance that will be measured for new suspensions in 1998. Exhibit 4 shows the vertical acceleration performance measured from Chicago to Milpitas, California. Data has been normalized to 1,000 miles.

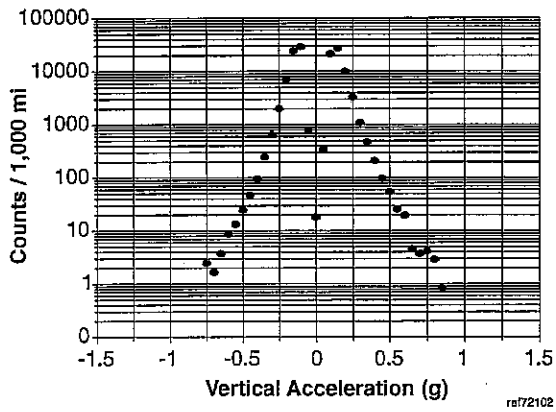


**Exhibit 4. Vertical Acceleration Events per 1,000 Miles — Baseline Truck in Tri-Level Autorack**

### ACKNOWLEDGMENT

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