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## Auto Parts Ride Quality in Railroad Service, Part 2

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### Summary

A series of tests to measure the ride quality performance in Ford Motor Company's auto parts transportation service are being conducted by Transportation Technology Center, Inc. (TTCI), under sponsorship from the Association of American Railroads (AAR) and the Union Pacific (UP) Railroad. The data will provide a basis for establishing ride quality expectations for the automobile industry. This *Technology Digest* discusses the second phase of testing (a TD on the first phase, titled "Auto Parts Ride Quality in Railroad Service, Part 1," was published as TD-03-011, June 2003).

Two suspension types were evaluated in the second test series: 1) the base suspension Swing Motion™ truck and, 2) a Frame Brace™ truck from Standard Car Truck Company. These suspensions were provided by UP with the cars. Tests demonstrated that the Frame Brace truck had similar performance to the Swing Motion truck in UP auto parts boxcar service.

The route for this comparison was from North Platte, Nebraska, to Los Angeles, California, in a high-speed UP train. Individual data collection systems were mounted in each car. In addition to the acceleration measurements, train speed and global positioning information were recorded. Performance data is from operation of the two cars coupled in the same train. A standard trip was established based upon distance at speed. This will ensure that an unusually slow or fast (future) trip does not influence the results. A later *Technology Digest* will show that direct comparison of performance measured in separate trains is not advisable.

Funding was provided through an industry Strategic Research Initiative, the Advanced Freight Car Truck Program. The initiative is working toward establishing an auto parts ride quality database in support of a future industry standard. The first attempt at data analysis uses a recommended practice already in place for transportation of finished automobiles (AAR RP803-98). AAR RP803-98 relies on counting acceleration events per 1,000 miles of railroad service. Continuous data for each car was collected from two lateral accelerometers, two vertical accelerometers, and two longitudinal accelerometers. This continuous data will enable data reprocessing if new ride quality criteria are established.



#### Suggested Distribution:

- Mechanical Dept.
- Automotive Marketing
- Planning & Analysis
- Safety

## INTRODUCTION AND CONCLUSIONS

AAR's subsidiary Transportation Technology Center, Inc., (TTCI) and UP conducted a series of tests to measure ride quality performance in auto parts boxcar service. Three individual tests were performed as part of the AAR Advanced Freight Car Truck Program. Separate issues of *Technology Digest* will be produced for each railroad service test. This is the second report in the series (first phase TD titled "Auto Parts Ride Quality in Railroad Service, Part 1" was published as TD-03-011, May 2003).

Success criteria have not been established for ride quality of auto parts boxcars. It is likely that the criteria established for auto rack cars in Recommended Practice 803-98 of AAR's Multilevel Manual will be close to what is needed for auto parts boxcars. A first step in defining success criteria for auto parts boxcars is to measure the performance of a car believed to be adequate and comparing its performance with differently equipped cars operating in the same train.

Using this approach, the AAR and UP tested five suspension types in high-speed service. Three separate trips were performed. Each trip included the car and suspension believed to have adequate performance. Car loading was mass simulated (blocks were set up to represent auto parts) at the Federal Railroad Administration's Transportation Technology Center (TTC) in Pueblo, Colorado. Wheel profiles can dominate high-speed stability performance. The wheel profiles in this test were simulated service worn and were the same for each car tested. Each car had 8,000-pound pre-load constant-contact side bearings (CCSBs) adjusted to correct setup height at TTC.

The second test was conducted with two suspension types: 1) the base suspension (Swing Motion™), and 2) a Standard Car Truck Company S-HD suspension with frame stiffening (Frame Brace™). The cars were operated coupled in high-speed UP service. Figure 1 shows an auto parts boxcar used in this test series.



Figure 1. Auto Parts Boxcar used in Railroad Service Test

Over-the-road performance data demonstrated the following about auto parts boxcar service:

- The Frame Brace and Swing Motion suspensions had similar lateral performance.
- The Frame Brace and Swing Motion lateral performance were better than the criterion set forth for auto rack performance in RP803-98.
- The Swing Motion and Frame Brace exceeded the vertical acceleration counts per 1,000-mile RP803-98 criterion.
- The Swing Motion exceeded the maximum vertical acceleration criterion of 1.0 g in the RP803-98 counts per 1,000 miles.
- The Frame Brace exceeded the maximum vertical acceleration criterion in RP803-98.

## BACKGROUND

Auto parts boxcar service remains an important business segment for North American railroads. Shipping by rail remains the most cost effective method to deliver auto parts when parts damage is minimized and transit time is consistent. The automotive industry is participating in efforts to maintain rail shipment quality to acceptable standards.

A panel of automobile and railroad industry representatives meets on a regular basis to address rail transportation issues. One issue is ride quality in auto parts transportation. It is possible for rail ride quality to be better than highway ride quality. Reliable high-speed stability performance to limit repetitive lateral rigid-body accelerations is a primary goal of the auto industry.

A secondary goal is to limit vertical accelerations from harmonic bounce or from railcar reaction to changes in vertical track stiffness such as road crossings, bridge approaches, and switches. A further ride quality goal is to control longitudinal accelerations in train handling. Although longitudinal accelerations are important, they cannot be improved with better truck designs and will not be discussed here.

### High-Speed Stability

Methods to improve high-speed stability in a freight car suspension generally involve increasing the resistance to relative motion (warp) of the truck side frames, providing some method of lateral damping to attenuate yaw motion of the car, and employing CCSBs to increase truck rotation resistance.

Good high-speed stability will limit the number of lateral acceleration events encountered. A typical frequency of lateral high-speed instability is a bit more than two cycles per second. The auto rack ride quality recommended practice criterion allows less than 100 counts of lateral acceleration greater than 0.35 g per 1,000 miles. At two cycles per second, high-speed instability could exceed this criterion in just 500 seconds.

# TECHNOLOGY DIGEST

Most suspensions equipped with CCSBs will provide acceptable high-speed stability when the truck components are in new condition. Worn truck components and worn wheel profiles will increase the likelihood of high-speed instability. Tight track gage and track deviations will also reduce the likelihood of stable performance.

## SUSPENSIONS TESTED

### Swing Motion Truck

The Swing Motion truck from Meridian Rail Company (Figure 2) is designed to improve high-speed stability performance by two methods. The first method is through damping of lateral motions by allowing the side frames to swing laterally. This lateral degree of freedom decouples axle and truck motion from the car body. The second is to increase warp stiffness with a shear plate that ties the two side frames together.



Figure 2. Swing Motion Truck

### Frame Brace Truck

The Standard Car Truck Company Frame Brace suspension (Figure 3) uses diagonal connections between the two side frames to increase truck squaring and improve high-speed stability.



Figure 3. Frame Brace Truck

### Standard Speed Profile

Figure 4 shows the speed profile that will be used to adjust the data for each trip. This is done to limit trip-to-trip variations. The data in this *Technology Digest* was collected for the two cars coupled.

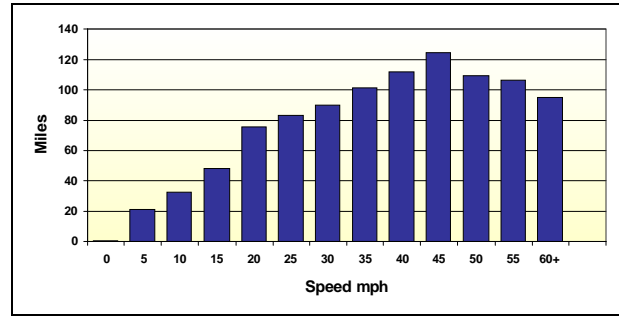


Figure 4. Speed Profile

## LATERAL RIDE QUALITY

Figure 5 shows the lateral counts per 1,000 miles for both suspensions. The data has been adjusted to fit a standard speed profile. An adjustment was accomplished by placing the acceleration events into 5-mph speed bins and then normalizing by multiplying measured events by the ratio of distance traveled at that speed range divided by the distance in the standard speed profile.

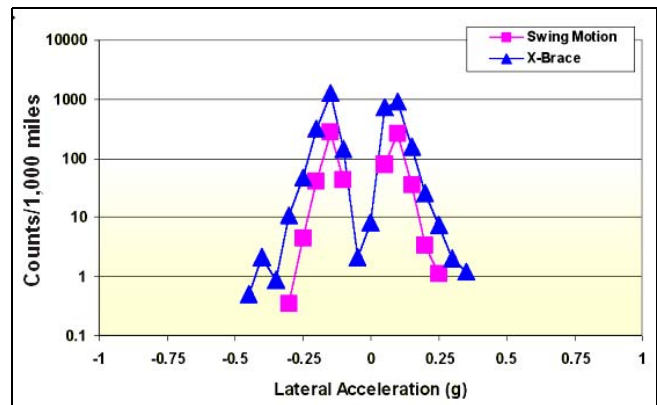


Figure 5. Lateral Acceleration Events per 1,000 Miles

Table 1 compares the lateral events to the auto rack recommended practice criteria. The criteria allow no more than 100 counts larger than 0.35 g per 1,000 miles and allow no counts larger than 0.75 g. The Frame Brace and the Swing Motion trucks met both lateral acceleration criteria.

Table 1. Lateral Ride Quality Events and Criteria

Truck	Criteria	Measured Events	Criteria	Measured Events	Criteria Met?
Swing Motion A-End	100> 0.35 g	0.0	0>0.75 g	0.0	Yes
Swing Motion B-End	100> 0.35 g	0.0	0>0.75 g	0.0	Yes
Frame Brace A-End	100> 0.35 g	2.0	0>0.75 g	0.0	Yes
Frame Brace B-End	100> 0.35 g	3.8	0>0.75 g	0.0	Yes

## VERTICAL RIDE QUALITY

Figure 6 shows the vertical acceleration events for both trucks. Table 2 compares the vertical performance to the auto rack recommended practice ride quality criteria. The Swing Motion truck had better performance than the Frame Brace truck in counts greater than 0.5 g per 1,000 miles. The Frame Brace truck had better performance in limiting events greater than 1.0 g. Neither truck met the vertical acceleration performance criteria.

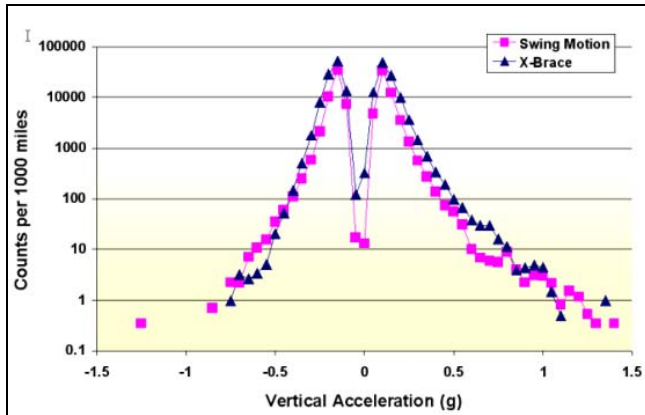


Figure 6. Vertical Acceleration Events Per 1,000 Miles

Table 2. Vertical Ride Quality Events and Criteria

Truck	Criterion	Measured Events	Criterion	Measured Events	Criteria Met?
Swing Motion A-end	100> 0.50 g	135.4	0>1.00 g	8.5	No
Swing Motion B-end	100> 0.50 g	187.2	0>1.00 g	15.7	No
Frame Brace A-end	100> 0.50 g	325.1	0>1.00 g	8.1	No
Frame Brace B-end	100> 0.50 g	155.0	0>1.00 g	4.2	No

## SUMMARY

This test demonstrates that the Frame Brace truck has similar performance to the Swing Motion truck in UP auto parts service.

For convenience, data was compared to a standard established for transporting finishing automobiles. This standard may not be appropriate for transporting auto parts.

The data will provide a basis for establishing ride quality expectations.

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