

Work performed by Transportation Technology Center, Inc., a subsidiary of the Association of American Railroads.
Contact **Ken Rownd**, (719) 584-0552 with questions or concerns regarding this *Technology Digest*. E-mail: ken_rownd@ttci.aar.com.

Auto Parts Ride Quality in Railroad Service, Part 1

by Ken Rownd and Darrell Iler

Summary

The Association of American Railroads (AAR) and Union Pacific (UP) are conducting a series of tests to measure the ride quality performance in Ford Motor Company's auto parts transportation service. The data will provide a basis for establishing ride quality expectations to the automobile industry.

Three suspension types were evaluated in the first test series: 1) a base suspension (Swing Motion); 2) a Standard Car Truck Company S-2E suspension; and 3) a service worn Barber S-2C truck. These were the trucks under the cars as provided by UP. Tests demonstrated that:

- The S-2E truck and the Swing Motion truck displayed similar performance operating in UP auto parts boxcar service.
- The worn S-2C truck had many times more vertical and lateral acceleration events than the S-2E or Swing Motion.
- The worn S-2C truck exhibited high-speed instability in UP service.

The route for this comparison is Pueblo, Colorado 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 three 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, Advanced Freight Car 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 transporting finished automobiles (RP803-98). The RP803-98 recommended practice relies on counting acceleration events per 1,000 miles of railroad service.

Continuous data for each car was collected for two lateral accelerometers, two vertical accelerometers, and two longitudinal accelerometers. Continuous data will enable data re-processing if new ride quality criteria are established.

Suggested Distribution:

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



INTRODUCTION AND CONCLUSIONS

The Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads (AAR), and Union Pacific (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.

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 TTCI. Wheel profiles can dominate high-speed stability performance. The wheel profiles 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.

The test described here included three suspension types: 1) a base suspension (Swing Motion); 2) a Standard Car Truck Company S-2E suspension; and 3) a service worn Barber S-2C truck. 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 S-2E and Swing Motion suspensions had similar lateral performance.

- The S-2E and Swing Motion lateral performance were better than the criterion set forth for auto rack performance in RP803-98.
- The Swing Motion and S-2E exceeded the RP803-98 criterion of vertical acceleration counts per 1,000 miles above 0.5g.
- Both the Swing Motion and S-2E exceeded the maximum vertical acceleration criterion of 1.0 g in RP803-98.
- The worn S-2C truck exceeded lateral and vertical criterion in RP803-98.
- The worn S-2C truck exhibited high-speed instability in UP service.

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 and service time are kept in control. 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 rail car 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 boxcar, and employing CCSB 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 more than 2 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 2 cycles per second,

high-speed instability could exceed this criterion in just 500 seconds.

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 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

S-2E Truck

The Standard Car Truck Company S-2E suspension (Figure 3) uses a split-wedge friction damper to increase truck squaring and improve high-speed stability. Standard Car Truck Company tuned the vertical springs to provide optimum performance for auto parts boxcar service.



Figure 3. S-2E Truck

S-2C Truck

The worn S-2C suspension is typical of worn suspensions found under existing cars. This suspension relies on CCSBs to provide high-speed stability.

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 all three cars coupled.

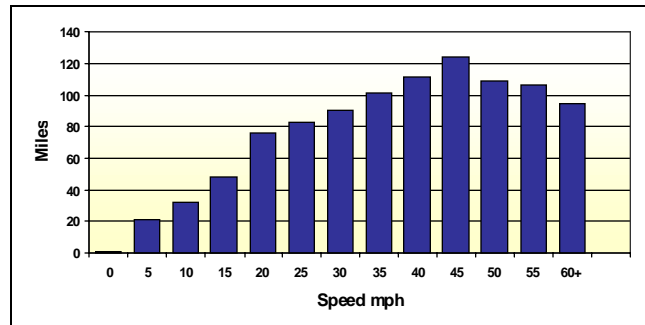


Figure 4. Speed Profile

LATERAL RIDE QUALITY

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

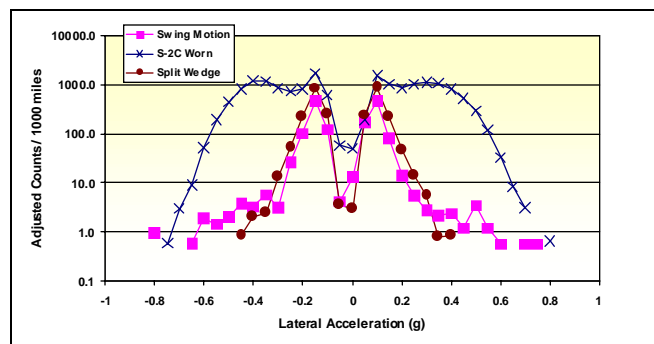


Figure 5. Lateral Acceleration Events per 1,000 Miles

Table 1 compares the lateral events to the auto rack 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 S-2E truck met both criteria. The Swing Motion met the count per 1,000-mile criteria, but did not meet the maximum criterion of 0.75 g — exceeding 1.6 times per 1,000 miles. The S-2C truck did not meet either criterion.

Table 1. Lateral Ride Quality Events and Criteria

Truck	Criteria	Measured Events	Criteria	Measured Events	Criteria Met?
Swing Motion	100 > 0.35 g	26.8	0 > 0.75 g	1.6	No
S-2E	100 > 0.35 g	4.6	0 > 0.75 g	0.0	Yes
S-2C (worn)	100 > 0.35 g	5,687.5	0 > 0.75 g	0.7	No

The worn S-2C truck was stable as tested at Transportation Technology Center prior to the railroad service data trip. As Figure 5 shows, this truck did experience high-speed instability in UP service. The result was lateral acceleration events several times that observed for the other two boxcars. As Figure 6 shows, the lateral criterion was exceeded 38 times in only 10 seconds. The other end of the car was active but did not exceed the criterion in this time period. The criterion is ± 0.35 g.

VERTICAL RIDE QUALITY

Figure 7 shows the vertical acceleration events for all three trucks. Table 2 compares the vertical performance to the auto rack ride quality criteria. The Swing Motion truck had slightly better performance than the S-2E in counts greater than 0.5 g per 1,000 miles. The S-2E truck had better performance in limiting events greater than 1.0 g. The S-2C worn truck had inferior vertical performance.

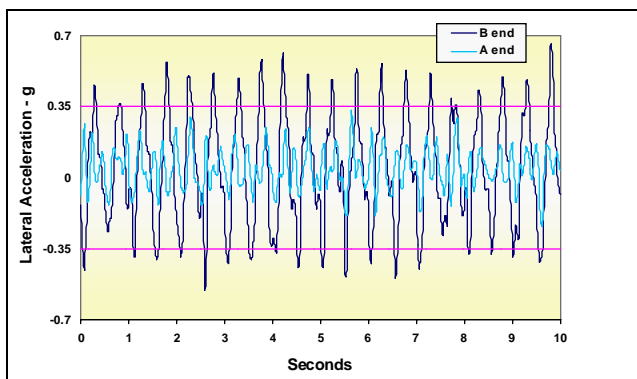


Figure 6. S-2C Truck Lateral Instability

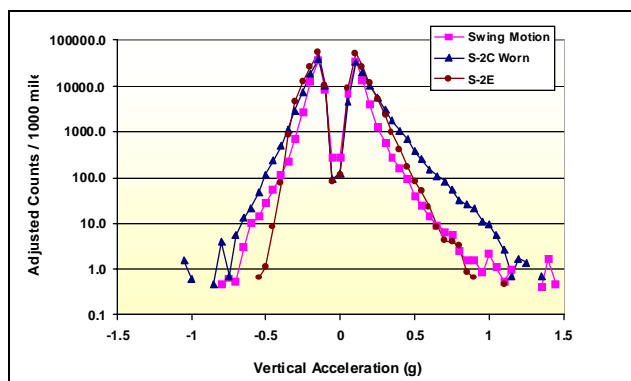


Figure 7. Vertical Acceleration Events per 1,000 Miles

Table 2. Vertical Ride Quality Events and Criteria

Truck	Criterion	Measured Events	Criterion	Measured Events	Criteria Met?
Swing Motion	100 > 0.50g	140.5	0 > 1.00 g	7.6	No
S-2E	100 > 0.50g	175.8	0 > 1.00 g	0.4	No
S-2C (worn)	100 > 0.50g	1,231.1	0 > 1.00 g	23.7	No

SUMMARY

These tests demonstrate that the S-2E truck has similar performance to the Swing Motion truck operating in UP auto parts operating 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. The worn S-2C truck had many times more vertical and lateral acceleration events than the S-2E or Swing Motion. The worn S-2C truck exhibited high-speed instability in UP service.

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