

## Assessing Constant Contact Side Bearing Performance for a Long Tank Car

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### Summary

Track tests and modeling studies indicate that long-travel\* constant contact side bearings (CCSBs) installed on a long tank car provide the best overall performance in combined issues of curving, vertical load equalization, and high-speed stability. CCSBs generally performed well in comparison to double rollers in loaded truck turning resistance tests.

Transportation Technology Center, Inc. (TTCI) conducted these tests on behalf of the Association of American Railroads' Equipment Engineering and Mechanical Research committees, in response to reducing the stress state of the railroad. A 2001 directive stipulates that all interchange railcars be equipped with CCSBs. The Equipment Engineering Committee has recommended to the Technical Services Working Committee that after January 1, 2003, all new cars (or cars that have been rebuilt, given extended service, or increased gross rail load) be equipped with long-travel CCSBs in accordance with *AAR Office Manual* Rule 88. The rest of the fleet will be considered after that date. The test plan called for both track testing and modeling of four railcar styles. In addition, six separate car designs were exclusively modeled.

This *Technology Digest* focuses on tests performed on a long tank car, TILX 301711, at the Federal Railroad Administration's Transportation Technology Center (TTC) near Pueblo, Colorado. A standard double roller side bearing was evaluated along with four general CCSB designs: long-travel, long-travel roller assist, standard-travel, and standard-travel roller assist. Tracks used at TTC included the Wheel Rail Mechanism Loop, which includes a dynamic curve section, and the Transit Test Track. Test requirements mandated the use of railcars and track in good condition; thus, results presented in this report only apply to similar conditions.



Tank Car TILX 301711

\* Throughout this *Technology Digest*, the reference "long-travel" is equivalent to extended travel or any device with 5/8-inch of travel.

### Suggested Distribution:

- Mechanical
- Planning & Analysis
- Car Department
- Safety



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## INTRODUCTION

The North American rail industry has made a concerted effort to reduce the stress state of the railroads. Constant contact side bearings (CCSBs) are an integral part of improving a railcar's overall performance. In 2002, the Association of American Railroads (AAR) Mechanical Research Committee and Equipment Engineering Committee (EEC) approved a test plan to begin evaluating general styles of CCSBs. The tests included loaded/empty curving, dynamic curving, limiting/bunched spirals, and empty high-speed stability on a long tank car. The tests were performed and results evaluated using methods outlined in M-1001, Chapter XI of the AAR's *Manual of Standards and Recommended Practices*. Transportation Technology Center, Inc. (TTCI), a subsidiary of the AAR, conducted these tests.

Cars with some accumulation of service mileage and broken-in trucks were desired to minimize anomalous effects caused by new equipment. Additionally, the EEC wished to use CCSBs that had a period of usage as well. However, for testing purposes, there was not a controlled method of selecting "used" CCSBs since these devices are worn or "broken in" by vehicle cyclic action that is usually independent of mileage. For this reason, manufacturers supplied new CCSBs that were then "pre-cycled" to help minimize break-in anomalies. Wheel profiles used during the test included AAR-1B for all curve tests and 100,000-mile profiles (KR wheels) for high-speed stability tests.

## TEST SETUP

Trucks used during empty tests were new, 110-ton Barber S-2-HD cast in 08-99 with a standard suspension (seven D5 outer coil springs, six D5 inner coil springs). Loaded tests were performed with the higher mileage truck from the aluminum gondola previously tested (TD-02-021). The lightweight and load limits were 98,200 and 164,800 pounds, respectively. Car length was 66 feet over strikers with truck centers of 55 feet. Side bearings were tested without lubrication and center plate bowls were left in dry condition as received. The car was new and had acquired less than 5,000 service miles prior to testing. In loaded tests, the tank was filled with water resulting in a

center of gravity below the normal location. The following side bearing designs were selected:

- Double Roller (DR)
- Standard-travel Constant Contact (ST)
- Long-travel Constant Contact (LT)
- Long-travel Constant Contact with Roller Assist (LTRA)
- Standard-travel Constant Contact with Roller Assist (STRA) *Loaded Only*

## CHAPTER XI PERFORMANCE

Car tests were performed loaded and empty using Chapter XI criteria in steady state curving, spiral negotiation, and dynamic curving. High-speed stability testing was performed with the car empty, using high-mileage wheel profiles at top speeds of 60 mph. An unstable car at speeds below 60 mph does not meet high-speed stability criteria. Exhibit 1 summarizes the results.

**Exhibit 1. Chapter XI Performance Summary**

	DR	ST	LT	LTRA	STRA
Empty Spiral	Not met	Not met	Met	Met	
Empty Curving	Met	Met	Met	Met	
Empty Dynamic	Not met	Not met	Met	Met	
Loaded Spiral	Met	Met	Met	Met	Met
Loaded Curving	Met	Met	Met	Met	Met
Loaded Dynamic	Met	Met	Met	Met	Met
Empty Hunting Curve	Not Met	Met	Met	Met	
Empty Hunting Tangent	Not Met	Met	Met	Met	

A closer look at the performance in empty dynamic curving reveals that the double-roller design could not complete the test, and the standard travel CCSB exceeds the 1.0 L/V criteria. The best performance occurred using long-travel designs (Exhibit 2). Exhibit 3 is a demonstration of the empty dynamic curving performance. Note that the standard travel side bearing design caused the vertical load to fall below the Chapter XI limit of 10 percent.

Hunting tests were performed in both curved and tangent track. Results from both regimes were similar with respect to Chapter XI criteria. Exhibit 4 provides comparative results on the performance trends for the side bearings tested. In this case any CCSB design provided sufficient control to maintain stability.

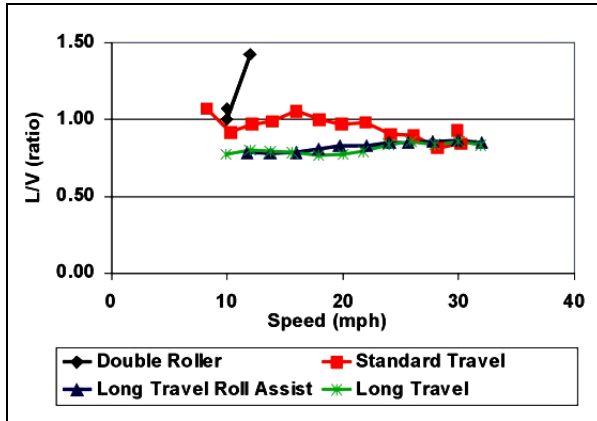


Exhibit 2. Empty Dynamic Curve Performance

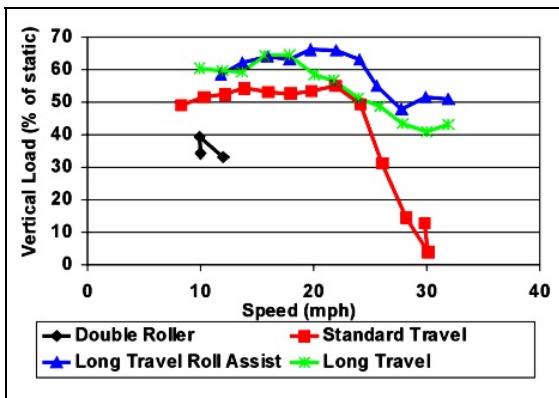


Exhibit 3. Empty Dynamic Curve Performance

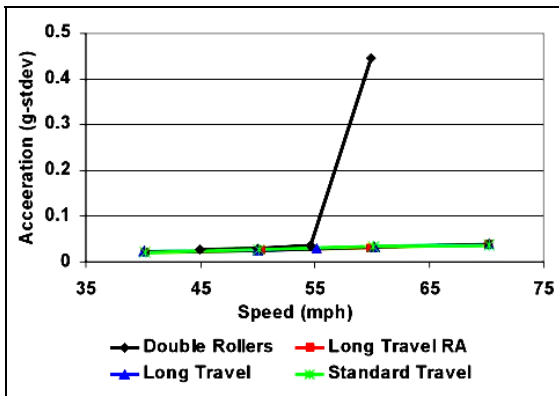


Exhibit 4. High Speed Stability Performance

### TRUCK TURNING MOMENT

It is known that CCSBs potentially contribute to an increase in the truck turning resistance on a given railcar — at issue is how much they contribute. Data was collected during curving tests to allow for truck turning moment calculations and analysis of truck warp measurements. Loaded car results show the long-travel CCSBs had equivalent to slightly

lower truck turning resistance values than the double rollers. Tank cars have a long truck spacing and a rigid car body resulting in higher loads supported by side bearings when negotiating track spirals. As trucks using double rollers or standard travel CCSBs negotiate the spiral, the interface between the side bearing and car body will experience significant loads once the travel is used up. The final outcome when negotiating curves will be higher truck turning values. A long-travel design provides relief as it allows 3/8 inch more truck roll response before side bearing travel bottoms.

### VERTICAL LOAD EQUALIZATION

Long-travel CCSBs provide better vertical load equalization in spirals when cars are torsionally stiff and have medium to long truck centers. Sufficient vertical load is vital for controlling L/V ratios and flange climb derailments. In spirals, the entire car must respond to maintain vertical loads safely. From a vertical suspension perspective, a railcar is a series of springs including the suspension, CCSBs, and car body torsional stiffness.

The long tank car is challenged in vertical load equalization due to the truck center. Measurements found that long travel CCSB designs provided higher vertical sustained wheel loads compared to rollers and standard travel CCSBs in empty car tests (2-4 kips), as shown in Exhibit 5. This is due to the additional side bearing travel to negotiate the spiral, (twist rate = 1 in./20 ft.) and given the long, 55-foot truck centers. In loaded tests, long-travel side bearings provided 5-10 kips more vertical load equalization in a track twist rate of 1 in./20 ft.

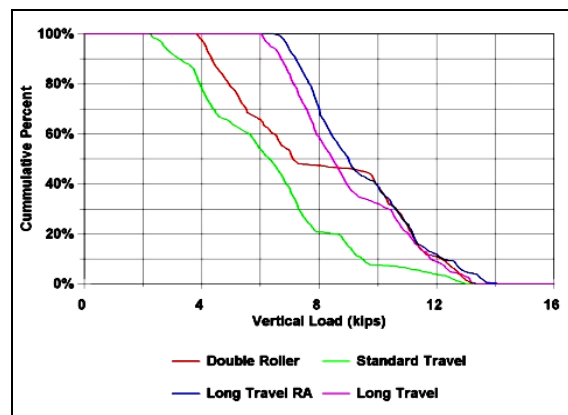
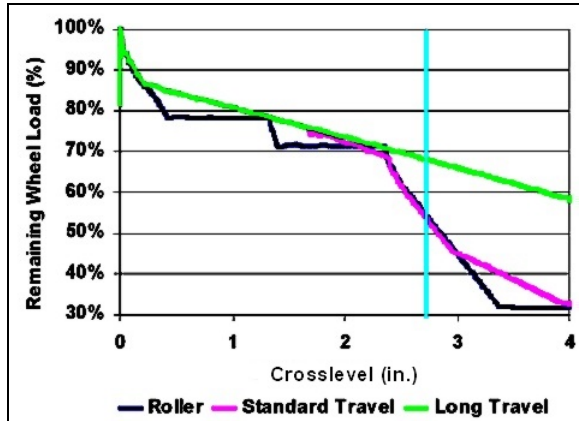


Exhibit 5. Empty Car, Lead Outside Wheel Vertical Load in a Spiral

## MODELING

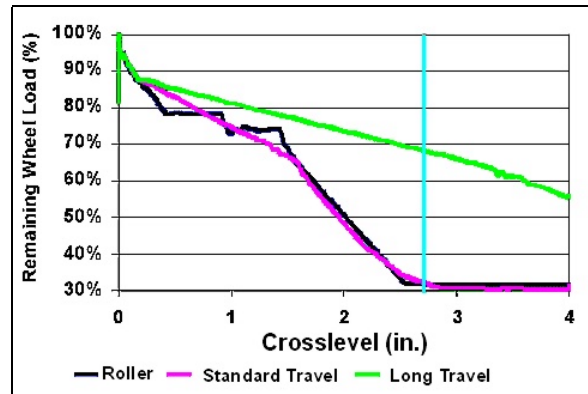
The model created for this railcar has been tuned and validated with on-track test results. Using model information, a vertical load plot (Exhibit 6) was constructed to illustrate the performance differences between the various side bearing applications. Exhibit 6 demonstrates the percent vertical load response of the long tank car in spirals.



**Exhibit 6. Empty Car, Lead Outside Wheel Vertical Load, Modeling Results**

The light blue vertical line indicates the tank car's performance in the limiting spiral. Note the long travel design is predicted to provide more vertical load equalization than the other types, which was confirmed in test.

Exhibit 7 demonstrates the effect of having 1/8-inch tight side bearings. The light blue line in this exhibit indicates the performance of the tank car in the limiting spiral. The long travel design is predicted to provide a vertical load nearly 40 percent higher than the other CCSB styles. *It is imperative that CCSBs be correctly installed and maintained as the wheel load differences between Exhibits 6 and 7 illustrate the degradation of performance when a car is operated with tight side bearings.* This also shows how long travel designs are more tolerant to the tight condition.



**Exhibit 7. Empty Car, Lead Outside Wheel Vertical Load, Modeling Results 1/8-inch Tight Setup**

## CONCLUSION

When combining the performance results from all regimes tested, long-travel CCSB designs perform favorably. Other side bearing designs tested had reduced performance in dynamic curving (rock and roll), vertical load equalization, and truck turning resistance. Should a railroad have performance problems with empty car rail climbs, car body roll in the truck center bowl, or severe spiral negotiation, the long-travel CCSB can provide measured improvements. The EEC has recommended to the Technical Services Working Committee that, after January 1, 2003, all new cars that are rebuilt, and cars given extended service or increased in gross rail load, be equipped with long-travel CCSBs in accordance with AAR Office Manual Rule 88.

**Note: Contact Darrell Iler at (719) 584-0546 with questions or comments about this document. E-mail: darrell\_iler@ttci.aar.com**

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