

The work described in this document was performed by Transportation Technology Center, Inc.,
a wholly owned subsidiary of the Association of American Railroads.

Testing of Constant Contact Side Bearings Using AAR Specification M-948

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Summary

TTCI has completed dynamic tests to determine how well typical side bearings in use today meet the requirements of AAR Specification M-948. In July 2005, two long-travel constant contact side bearings (CCSB) were evaluated by the Transportation Technology Center, Inc. (TTCI), a wholly owned subsidiary of the Association of American Railroads (AAR), using a portion of the new AAR Specification M-948 in the Manual of Standards and Recommended Practices. The two objectives of the study were first to evaluate the test methods required by M-948 and determine if it meets industry needs and second to see how well typical side bearings in use today meet the dynamic test portions of the specification. This is a challenging specification for CCSBs using a polymer spring design; however, most of the railcar population using CCSBs employs polymer spring elements. Since the rail industry needs CCSBs to endure higher speeds and higher mileage as well as low maintenance, this tough specification will better meet the railroads' needs.

Both of the side bearing designs met the premium level requirements for the vertical cycling test. The minimum performance for the standard service level is 50 percent, which means the side bearing cannot lose more than 50 percent of the initial pre-load value at the designed setup height. A side bearing rated for premium service cannot lose more than 35 percent (retains 65 percent) of the initial load. The rate at which the 1.5 million cycles are input into the side bearing may possibly have an effect on the outcome. The frequencies selected for this test are documented within the report, but are generally related to those experienced in service.

Both side bearings met requirements for premium service in the simulated service test. Following the test, some observations were severe heat damage to the polymer spring element and severe galling of the steel surfaces. A heat-damaged element from rail service is not an unlikely occurrence; however, neither this author nor the field representatives from CCSB suppliers have observed galled surfaces in the field that compare to the lab test. In spite of the observations, both long-travel CCSBs' performance still met premium requirements in the simulated service wear test.

Recommendations have been made to AAR's Equipment Engineering Committee that will better define the M-948 analysis process and help ensure consistent performance testing. The M-948 specification should provide reasonable confidence that side bearings meeting the requirements will also provide excellent service in the rail environment.



Introduction

In July 2005, two long-travel constant contact side bearings (CCSBs) were evaluated by the Transportation Technology Center, Inc. (TTCI), a wholly owned subsidiary of the Association of American Railroads (AAR), using a portion of the new AAR Specification M-948 in the Manual of Standards and Recommended Practices.

In June of 2005, the new AAR M-948 side bearing specification, in the AAR Manual of Standards, became effective. For many years the technology of side bearings (more specifically CCSBs) had progressed and been applied without any criteria for their intended function or use. The old specification focused on the performance standards of roller and block side bearings by ensuring that significant vertical loads could be imparted without fatigue or catastrophic failure.

Recently, as rail speeds have increased, the benefits of better high-speed stability were realized through the application of CCSBs. Over time, industry needs were expanded and in some applications, the traditional CCSBs proved inadequate resulting in a short-term life span. Occasionally constant contact devices would lose as much as 75 percent of their original effectiveness. The importance of developing a test specification that would challenge the capability of CCSBs was apparent.

In 2004, work began with an AAR Technical Advisory Group made up of side bearing manufacturers, car owners, and railroad members. The result of their efforts was embodied in the new M-948-2004 specification, in AAR’s Manual of Standards and Recommended Practices (Figure 1).

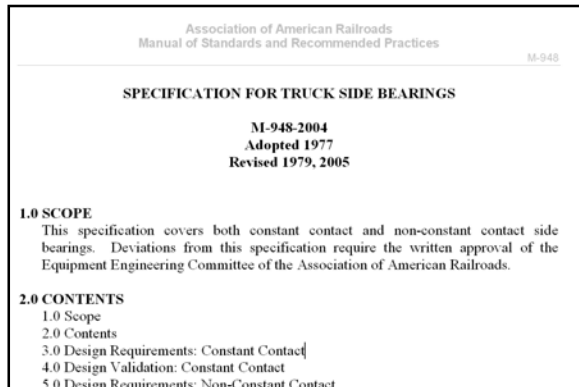


Figure 1: Newly Published M-948 Specification for Side Bearings with Emphasis on CCSB

This TD will provide results and methodologies from testing two typical long-travel side bearings. Values have purposely been modified or omitted to stress the process instead of the specific performance. There really is no effective way to determine expected mileage or life span of CCSBs, since factors like annual mileage, maximum speeds, and equipment condition have direct

influence on long-term performance. The lab test will only indicate performance capability in a harsh rail service environment.

Procedure

One objective of this particular study was to evaluate two of the test procedures that are documented in M-948. Those procedures were the Vertical Fatigue Cycling test (M-948 4.1.2) and the Simulated Service Test (M-948 4.1.3). The tests were performed on MTS controlled two-axis load fixtures (Figure 2) having a 50-kip vertical and 10- to 35-kip longitudinal capacity.



Figure 2: Dual Axis MTS Loading Frame Used to Test CCSB

The remaining requirements from M-948 were not performed, as they are generally associated with defining the function of CCSBs (such as preload and travel).

Vertical Testing

Vertical cycling consists of a series of displacements designed to stress the side bearing spring element. The displacements used are documented in M-948, however the frequency or time to complete the cycles is left to the proponents. For the two side bearings tested, frequency inputs were selected to match conditions experienced in service. For example, full compression of 0.63 inch occurs in spirals or for those cars experiencing severe carbody roll in the center bowl (a range of 0.1 to 1.5 Hz). Table 1 below documents the amplitudes and frequencies used in the lab tests.

Table 1: Frequencies Used With Specified M-948 Vertical Inputs

<i>Amplitude (in)</i>	<i>Frequencies (Hz)</i>	<i>M-948 Counts</i>
0.125	2.00	1,200,000
0.250	1.00	240,000
0.375	0.75	40,000
0.500	0.50	10,000
0.625	0.25	2,500

Vertical Test Results

The vertical test took a little over 10 days, at 24 hours per day, for each CCSB. A vertical stiffness plot was generated at the beginning and end of both tests to document the vertical fatigue performance. In addition, load values were recorded following the 30-minute static squeeze per M-948 requirements. Figures 3 and 4 illustrate the force/displacement curves for the two side bearings.

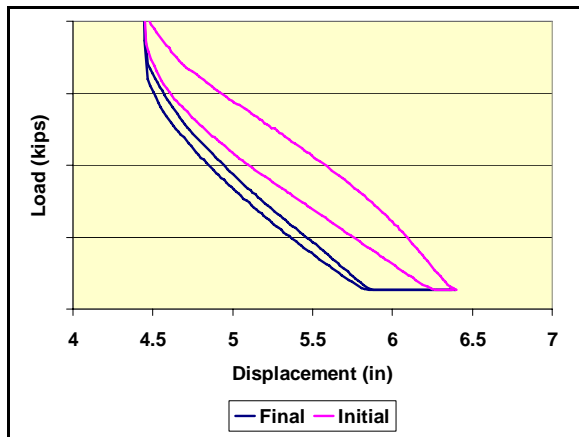


Figure 3: Vertical Load Performance CCSB-A

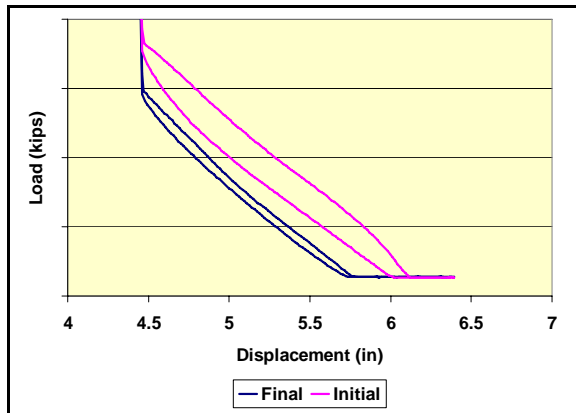


Figure 4: Vertical Load Performance CCSB-B

M-948 has two rating levels for the retained vertical load of a side bearing, which are standard (50 percent) and premium (65 percent). In our testing, both side bearings met the premium requirement for vertical fatigue performance.

The plots in Figures 3 and 4 are hysteresis curves that indicate the force variation in loading and unloading. This type of force path indicates minimal damping benefit. Note that if any damping benefit existed in the beginning, it had diminished to nearly nothing by the end of the test. From track tests at TTI, CCSB damping demonstrated potential benefits in empty carbody roll control for some railcar types. This was further investigated using a model of the same rail car. In Figure 5, the typical damping of a polymer-based

CCSB was doubled. The result was significant when comparing performance of a CCSB with no damping versus one with significant damping. Note that the minimum vertical wheel loads of the empty car improved from zero to about 5,000 pounds. No side bearings are currently available that possess this level of damping.

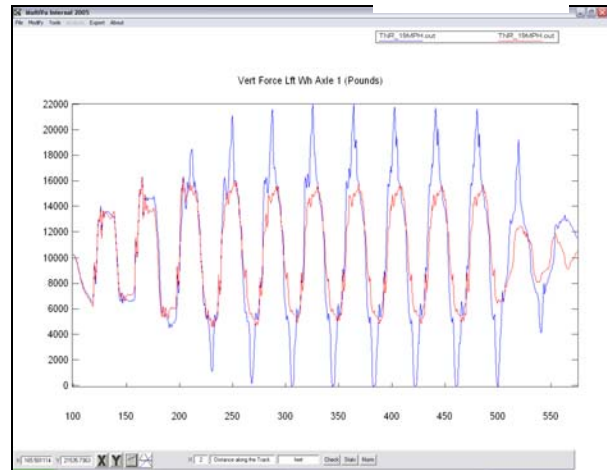


Figure 5: NUCARS Results Demonstrating the Benefit in Vertical Wheel Loading when CCSB Damping Levels are Twice of what is Currently Available

Simulated Service Testing

M-948 has a section that attempts to challenge the side bearing with the types of inputs experienced in high-speed stability and curving. These inputs were documented in the previous technology digest titled *Constant Contact Side Bearing Environment TD-05-027*.

At the beginning and end of the simulated service test, forces from both the longitudinal and vertical loads are recorded along with the longitudinal displacement. The cross-plot of longitudinal force with the displacement typically creates a parallelogram shape with some small steps where the verticals cross the X-axis. Figure 6 illustrates this shape (the green line) at the beginning of a test.

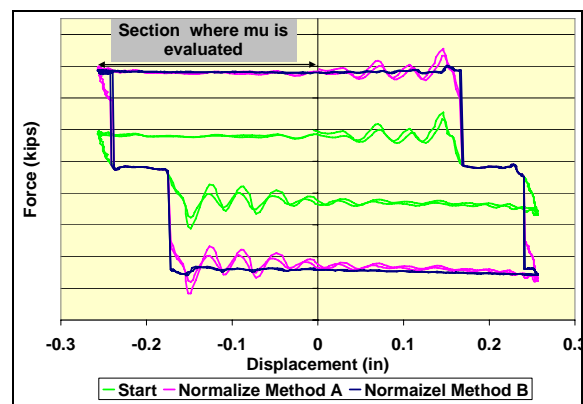


Figure 6: Example Hysteresis Curves from the Beginning of an M-948 Simulated Service Test

M-948 requirements state that a “typical” cycle should be recorded and then normalized to a frictional value (μ) of 0.6. This is illustrated in Figure 6 with either the blue or the pink lines. Two methods were tried which produce different shapes but their overall area was essentially the same. Method A focuses on the difference between the actual μ versus the specified μ of 0.6. For example, the average μ calculated from the designated region of the green line is 0.23. The difference from the specified μ of 0.6 is 0.37. By multiplying the vertical force by 0.37 and adding the longitudinal force we get a trace shaped like the pink line in Figure 6. Method B (the blue line) is achieved by multiplying μ by the vertical force; note that the curve is much less oscillatory. As stated earlier either method seems to provide the same area but method A retains more of the original shape.

Simulated Service Results

Figures 7 and 8 below illustrate the simulated service results from the two long-travel CCSB.

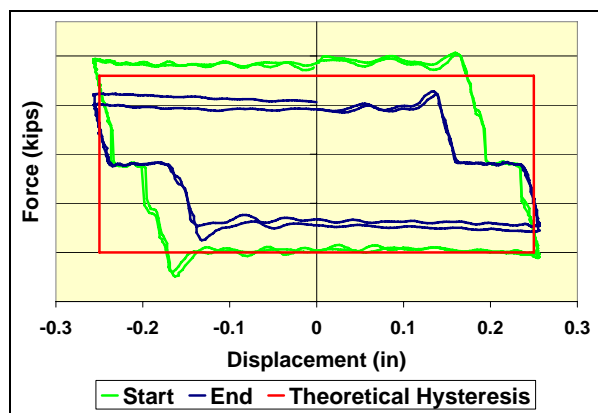


Figure 7: Initial and Final Hysteresis Curves Used to Calculate the Hysteresis Ratio for CCSB-A

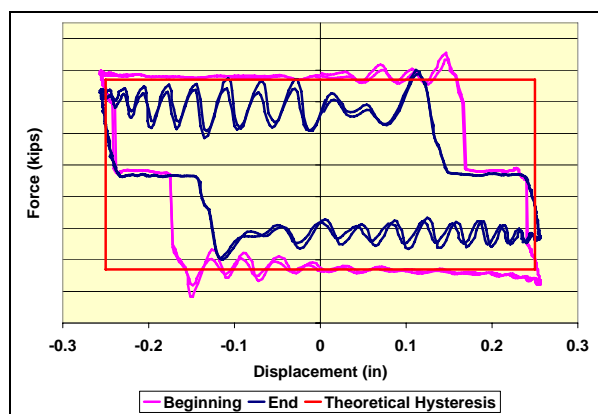


Figure 8: Initial and Final Hysteresis Curves Used to Calculate the Hysteresis Ratio for CCSB-B

For both figures the hysteresis plots shown have been normalized to a μ of 0.6. The M-948 specifications for the standard and premium levels are 25 percent and 45 percent respectively. Both CCSBs met hysteresis ratio requirements for the premium side bearing. The theoretical hysteresis curve is a box that is +/- 0.25 inch wide and +/- the designed preload times 0.6 (μ) high. The requisite answer is achieved by comparing the initial and final curves to the theoretical curve or by forming their ratios directly.

In addition to the hysteresis ratio, a side bearing is limited as to the amount of vertical shear before it begins slipping longitudinally (dynamic friction). In Figures 7 and 8, the horizontal steps of the loop near the X-axis are a measurement of this criterion. Looking at Figures 7 and 8, notice that the displacement before slip occurs was more than double when comparing the final and initial traces. The criterion states the difference between the end and the beginning cannot exceed 0.125 inch for the standard requirement and 0.0625 inch for a premium designation. Both side bearings met requirements for the premium performance. Following the test, the surfaces of both side bearings were severely galled as shown in Figure 9. The manufacturers of both CCSBs tested, stated that galling like this has not been witnessed in rail service.

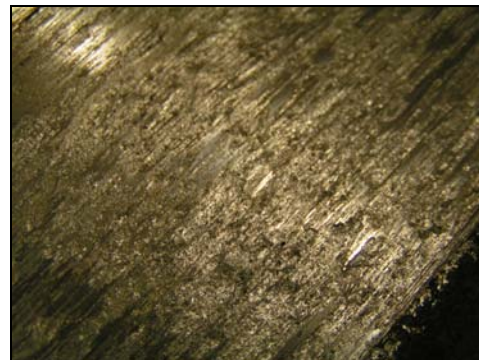


Figure 9: Galled Surface of a Lab Tested CCSB

Conclusion and Recommendations

AAR Specification M-948 challenges polymer-based CCSBs to meet the railroads needs. Other spring materials (steel) will likely not be challenged by this specification. However, most of the railcar population using CCSBs employs polymer spring elements. Since the rail industry needs CCSBs to endure higher speeds and higher mileage before performing any maintenance, a tough specification will better meet the railroads' needs. Having both side bearings meet criteria for premium performance, illustrates how today's designs have much improved performance as compared to legacy CCSBs that had limited/lost effectiveness in demanding rail services.

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