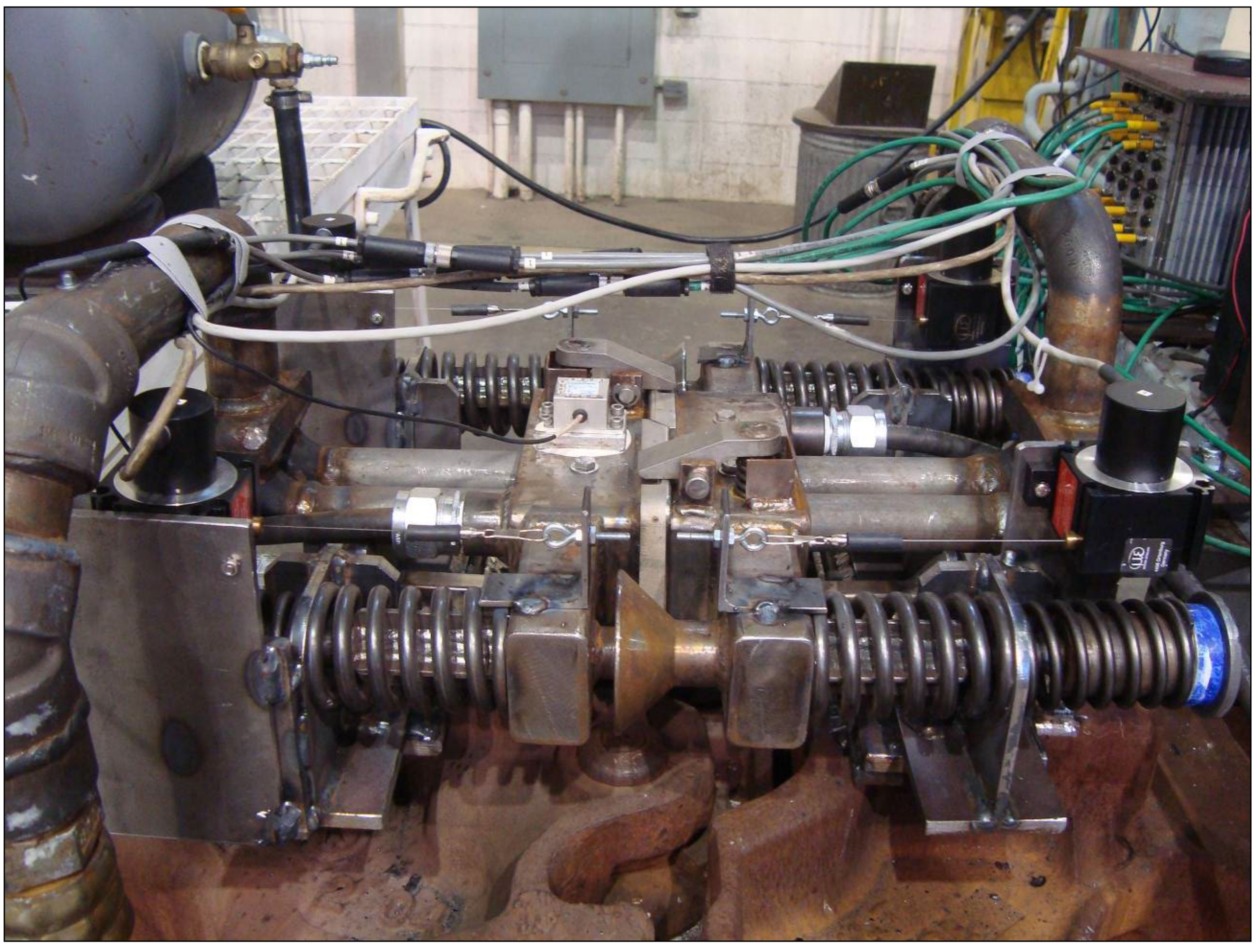
U.S. Department of Transportation

Federal Railroad Administration

Office of Research, Development and Technology
Washington, DC 20590

Advanced Component Testing: Tri-coupler Testing and Freight Car Electrical Power Supply System Demonstration



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14. ABSTRACT
FRA sponsored Transportation Technology Center, Inc. (TTCI) to perform evaluation tests on tri-couplers designed and produced by Sharma & Associates, Inc. (SA). SA designed and produced the freight car Electrical Power Supply System (EPSS), while TTCI provided support for the installation and demonstration. SA collected the test data and reported the test findings. Evaluation testing included impact tests and various trackworthiness assessment tests.

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Tri-coupler, freight car, Electrical Power Supply System, EPSS, track

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298-102

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION

Inches	0		1			2			3		4		5	
Centimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13

QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSIO

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

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Executive Summary

From October 2012 to April 2013, the Federal Railroad Administration (FRA) tasked Transportation Technology Center, Inc. (TTCI) to perform evaluation tests on tri-couplers designed and produced by Sharma & Associates, Inc. (SA).

TTCI also provided support for the installation and demonstration of the freight car Electrical Power Supply System (EPSS), also designed and produced by SA.

The tri-coupler evaluation test and EPSS demonstration included the installation of the components being used for testing and the trackworthiness testing of the components. SA collected the test data and reported the test findings. Evaluation testing included impact tests and various trackworthiness assessment tests.

1. Introduction

Sharma & Associates, Inc. (SA) designed and produced a freight car Electrical Power Supply System (EPSS). From October 2012 to April 2013, the Federal Railroad Administration (FRA) tasked Transportation Technology Center, Inc. (TTCI) to perform evaluation tests on SA's tri-couplers.

TTCI also provided support for the installation and demonstration of the freight car EPSS.

The tri-coupler evaluation test and EPSS demonstration included the installation of components used for testing and the trackworthiness testing of the components.

1.1 Objectives

SA tested the functionality of advanced components developed or under development.

1.2 Overall Approach

FRA furnished prototype components for evaluation and testing of its functionality and performance. Researchers carried out the evaluations on locomotives and cars from FRA's advanced concept train. The tests required a single car or a train to define operating practices and to obtain user feedback.

1.3 Scope

Currently, there are freight car components that can be improved for ease of operation or inspection and functionality. For example, when coupling two cars someone is required to get between the cars to connect the air. With advanced components such as a tri-coupler, the air is coupled during the car coupling process. When using an automatic angle cock operated from the side of the car or from the locomotive, the air can be safely opened up without needing railroad workers between the cars. These components should be durable and reliable, and optimized for functionality for ease of operation.

Based on this research, alternatives to current operating practices may be suggested, tested, and/or evaluated with demonstrations.

1.4 Organization of the Report

This report is organized into four sections: Section 1 introduces the work conducted. Section 2 describes the tri-coupler. Section 3 expans on the freight car EPSS. Section 4 provides a summary of the results produced by this work.

2. Tri-Coupler

TTCI performed evaluation tests on tri-couplers installed on the FRA advanced concept train. SA designed and produced the tri-coupler, and supplied the prototype for testing. SA collected the test data and reported on the test findings. Testing included impact tests and various trackworthiness assessment tests.

2.1 Procedure

A tri-coupler pod was mounted to the coupler on the A-end of the UTLX 96240 tank car and another tri-coupler pod was mounted on the A-end of the Union Pacific (UP) 72053 covered hopper car. Prior to testing, the tri-couplers were coupled and the trackworthiness testing began after installation. The trackworthiness tests included twist and roll, pitch and bounce, yaw and sway, and hunting, according to the criteria found in Chapter 11 of the Association of American Railroads' Manual of Standards and Recommended Practices (MSRP) [1]. Impact tests were performed at the completion of the trackworthiness testing.

The tri-coupler connected cars were subjected to the most severe track conditions and operating speeds possible without risking the safety of personnel and operating equipment, other than the tri-coupler pods.

The instrumentation used in the testing included:

- Instrumented wheelsets installed on the lead axle of each car
- Vertical, lateral, and longitudinal acceleration sensors installed on each end of the test cars
- Pneumatic path pressure through the tri-coupler
- Electrical connection continuity through the tri-coupler
- Impact speed of hammer car
- Video

2.2 Installation

The initial installation of the instrumentation on these two test cars was on the B-end of both cars. This proved to be problematic because of coupler wear. The tri-coupler pods were then mounted onto the A-end couplers of both cars. Figure 1 shows the tri-coupler pods installed onto the A-end couplers and connected. Installing an air tank on each car prevented any interference with the operation of the brake system.

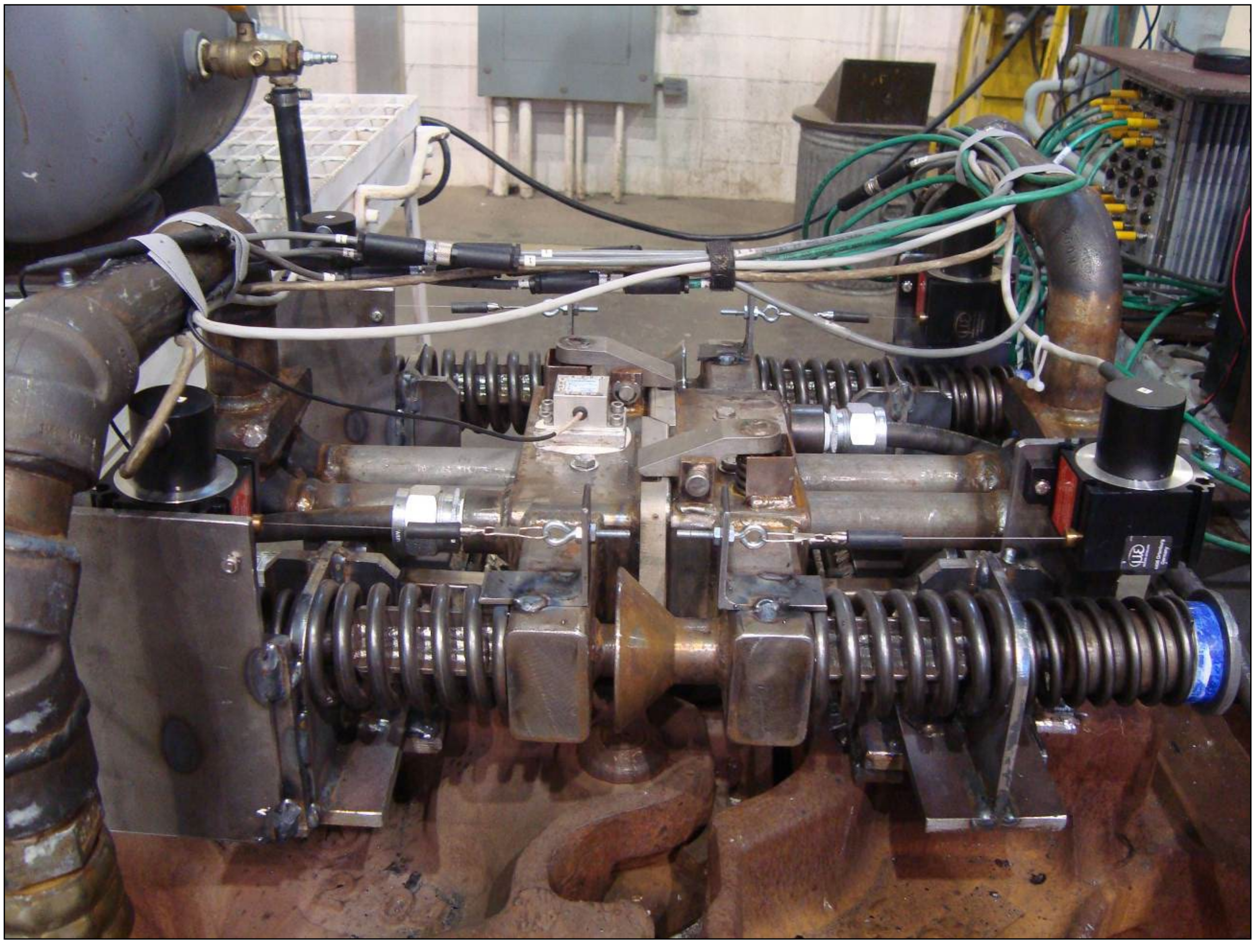

Figure 1. Installed Tri-Coupler Pods

2.3 Twist and Roll

Twist and roll simulates the roll modes of the carbodies. The twist and roll track section is comprised of 10 staggered perturbations with a wavelength of 39 ft and a cross-level of 0.75 in. This track section excites a rotation about the longitudinal axis through the center of mass for each car. Six test runs were made through the twist and roll track section. Test speeds started at 35 mph increasing at 5 mph increments until reaching maximum test criteria. The MSRP Chapter 11 testing criteria for the twist and roll section [1] are stated as: vertical force shall be above 10 percent of the average, and longitudinal force to vertical force ratio (L/V) shall be below 1. The test showed the L/V criterion was exceeded on a run at 40 mph. Due to the proximity of the twist and roll track section with the pitch and bounce track section, some runs started before the twist and roll track section to get enough speed before the pitch and bounce track section.

2.4 Pitch and Bounce

Pitch and bounce simulates the vertical oscillation of the carbodies. The pitch and bounce track section is comprised of 10 parallel perturbations with a wavelength of 39 ft and a maximum vertical amplitude of 0.75 in. This track section excites a rotation about the transverse axis through the center of mass for each car. Four test runs were made through the pitch and bounce section of track. Test speeds started at 40 mph increasing at 5 mph increments until test criteria were reached. The MSRP Chapter 11 testing criteria for the pitch and bounce section are listed as: vertical force shall be above 10 percent of the average, and L/V shall be below 1. The test showed the L/V criterion was exceeded on a run at 50 mph. Performing the fourth test run verified that the L/V criterion was exceeded during the pitch and bounce track section and was not caused during the transition between the twist and roll and the pitch and bounce track sections.

2.5 Hunting

Hunting simulates the sustained lateral oscillation of the axle between the wheel flanges. The hunting section was on tangent FRA Class 6 track on the Railroad Test Track. The wheels of the test cars had average worn wheel profiles. Test speeds started at 40 mph increasing at 5 mph increments until reaching the test criteria. The MSRP Chapter 11 testing criteria for the hunting section are listed as: vertical force shall be above 10 percent of the average, L/V shall be below 1, and carbody acceleration shall be below 0.13 g (new limit in Chapter 11). The old limit for acceleration of the carbody was set at 0.26 g. The test showed the acceleration criterion for the new limit exceeded 50 and 55 mph for the older limit.

2.6 Yaw and Sway

Yaw and sway simulates the roll and yaw body mode between coupled cars. The yaw and sway track section is comprised of five parallel perturbations with a wavelength of 39 ft and a maximum lateral amplitude of 1.25 in. This track section excites a rotation about the vertical axis through the center of mass for each car. Five test runs were made through the yaw and sway section of track. Test speeds started at 30 mph, increasing at 5 mph increments until reaching the test criteria. The MSRP Chapter 11 testing criteria for the yaw and sway section are listed as: vertical force shall be above 10 percent of the average, L/V shall be below 1, and carbody acceleration shall be below 0.13 g (new limit in Chapter 11). The old limit for acceleration of the carbody was set at 0.26 g. The test showed the acceleration criterion for the new limit exceeded 45 and 50 mph for the older limit.

2.7 Impact Test

The impact testing of the tri-couplers aided in verifying that the tri-couplers could survive impacts that might be encountered during revenue service. Impacts such as those encountered during train make-up or humping operations were simulated.

A hammer car was impacted into a string of three standing, empty cars. The impact string had the hand brake fully set on the last car (opposite end). A series of impacts was made on tangent track by the hammer car. Successive impacts were made at 3, 4, and 5 mph. After each impact, the tri-couplers were uncoupled and visually inspected for damage. Figure 2 shows a diagram of the test train. The tri-couplers were installed on the hammer car and on the first car of the anvil string. Figure 3 shows one of the tri-coupler pods after the impacts.

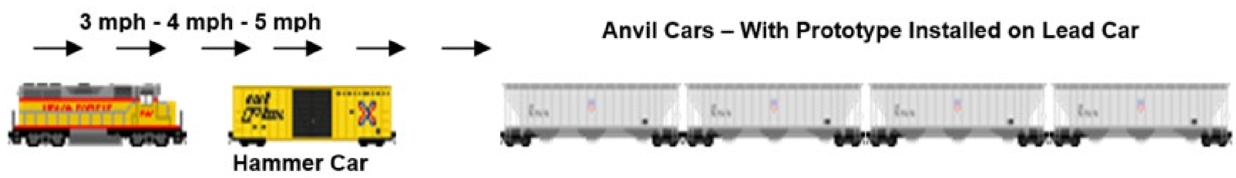

Figure 2. Impact Test Train Setup

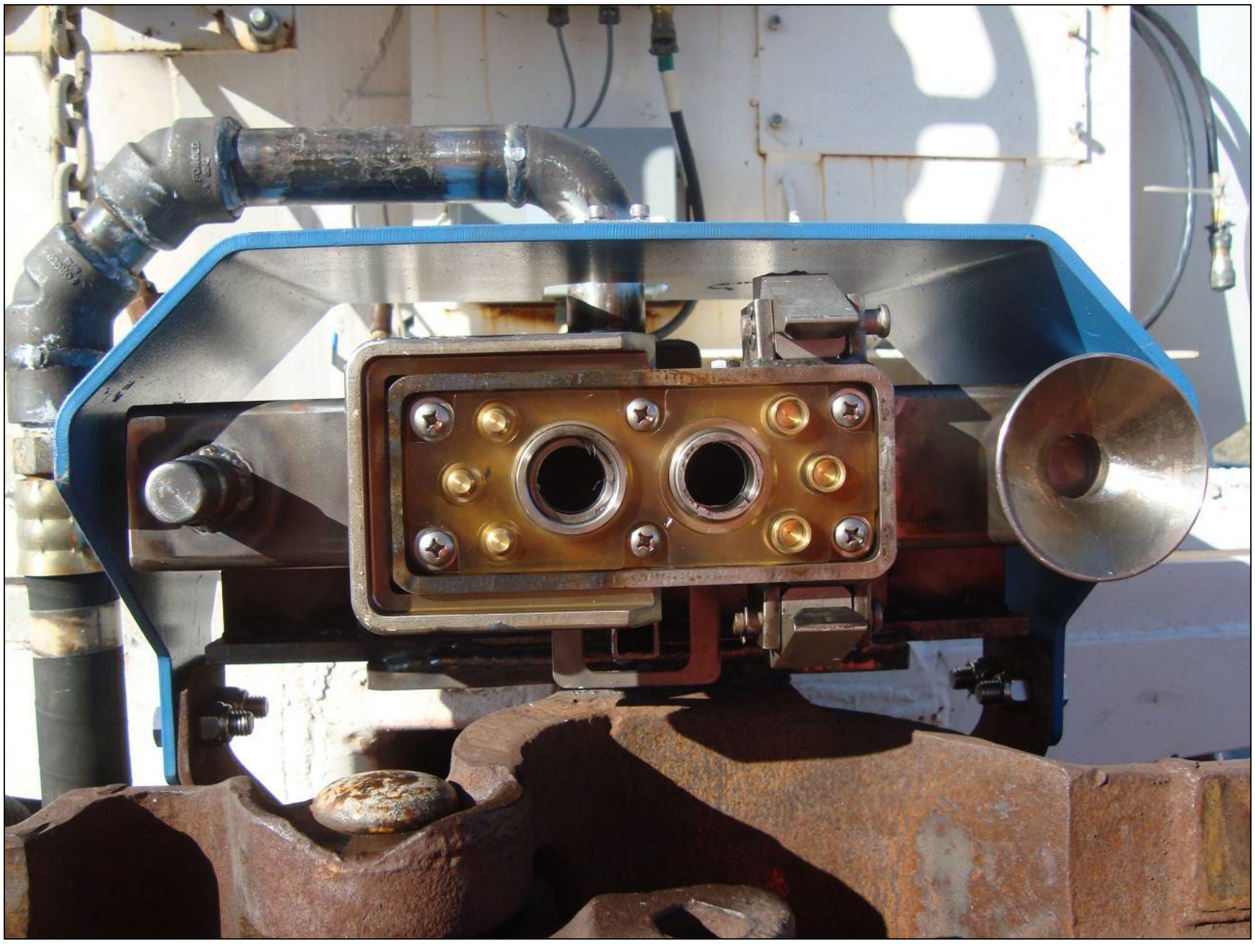

Figure 3. Tri-Coupler After Impact Testing

3. Freight Car Electrical Power Supply System

The EPSS was installed on a locomotive and two cars from the FRA advanced concept train. SA supplied the equipment for the EPSS, collected the test data, and reported the demonstration findings. The EPSS converts power from the locomotive to supply power to freight cars and is intended to allow monitoring and control of sensors, including the application/release of hand brakes, cut-levers, and angle cocks.

3.1 Procedure

The EPSS was installed on the FRA-2001 locomotive, the UTLX 96240 tank car, and the UP 72053 covered hopper car. After installation, assembly of the test train ensued along with a demonstration of the components. Electrical connections were tested at various stages of the demonstration.

3.2 Installation

The components installed on the locomotive were junction boxes next to the couplers and an inverter inside the short hood. Figure 4 shows the inverter after installation, and Figure 5 shows a junction box.

Figure 4. Inverter Inside FRA-2001

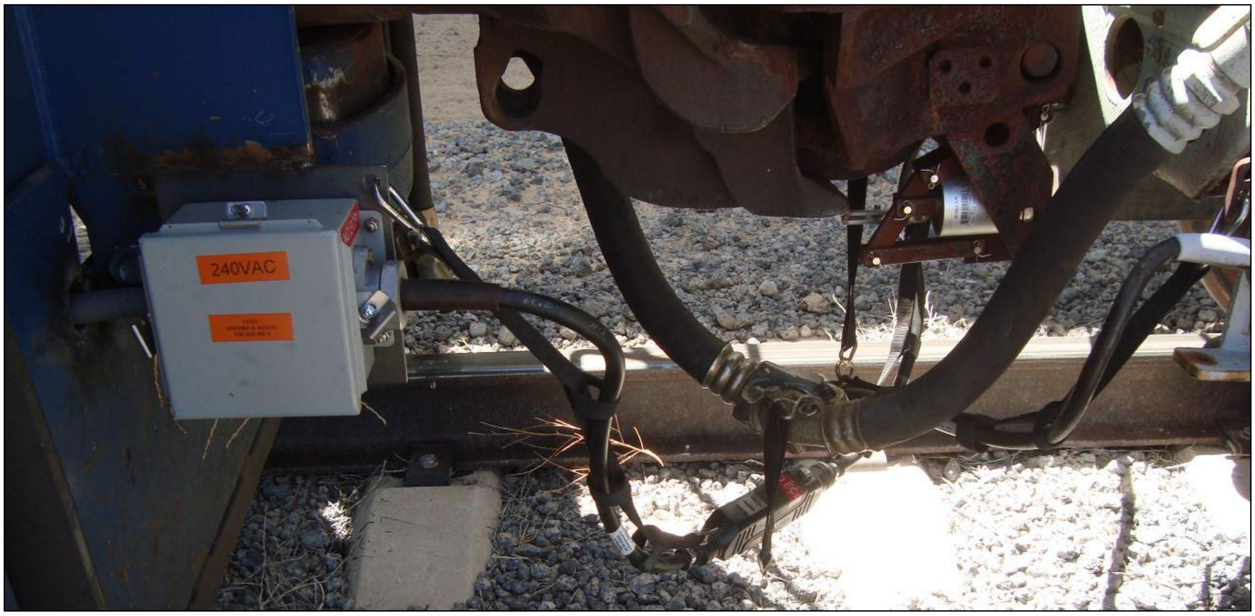

Figure 5. Junction Box

The components installed on the covered hopper and tank car were junction boxes next to the couplers, battery boxes, and side-mounted operation boxes. Figure 6 shows a battery box, and Figure 7 shows one of the side-mounted operation boxes.

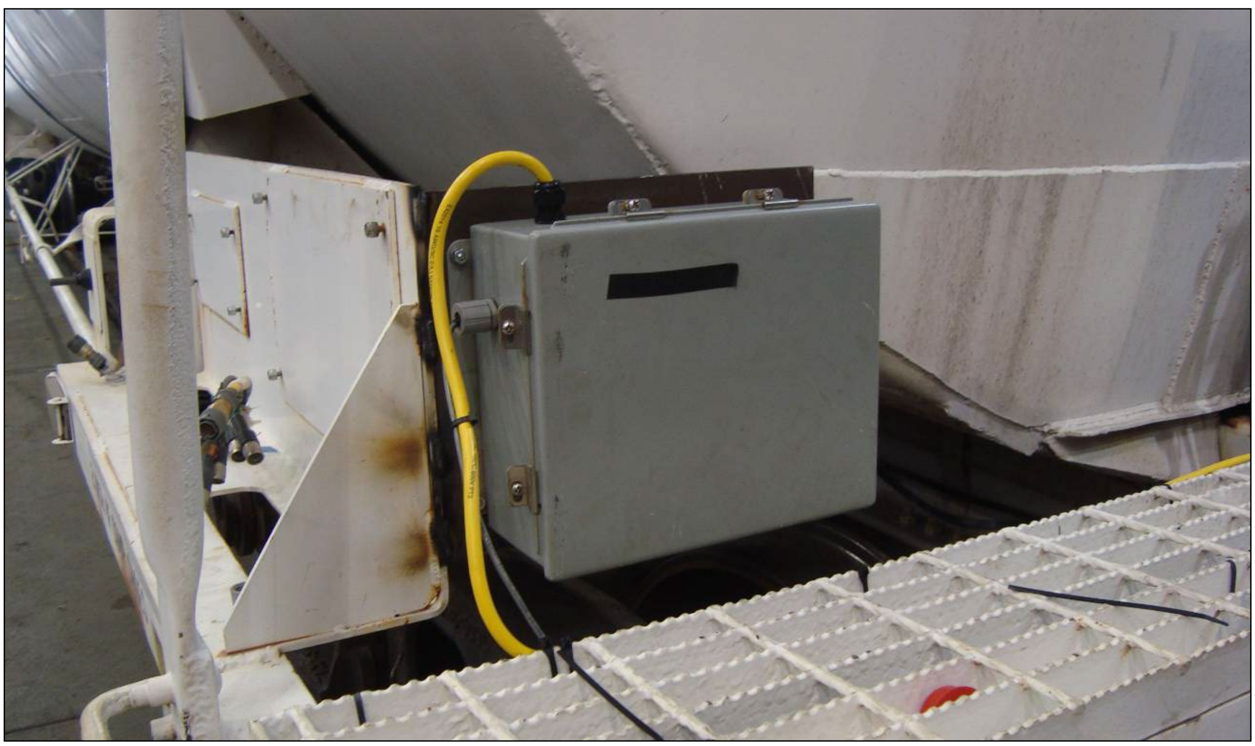

Figure 6. Battery Box

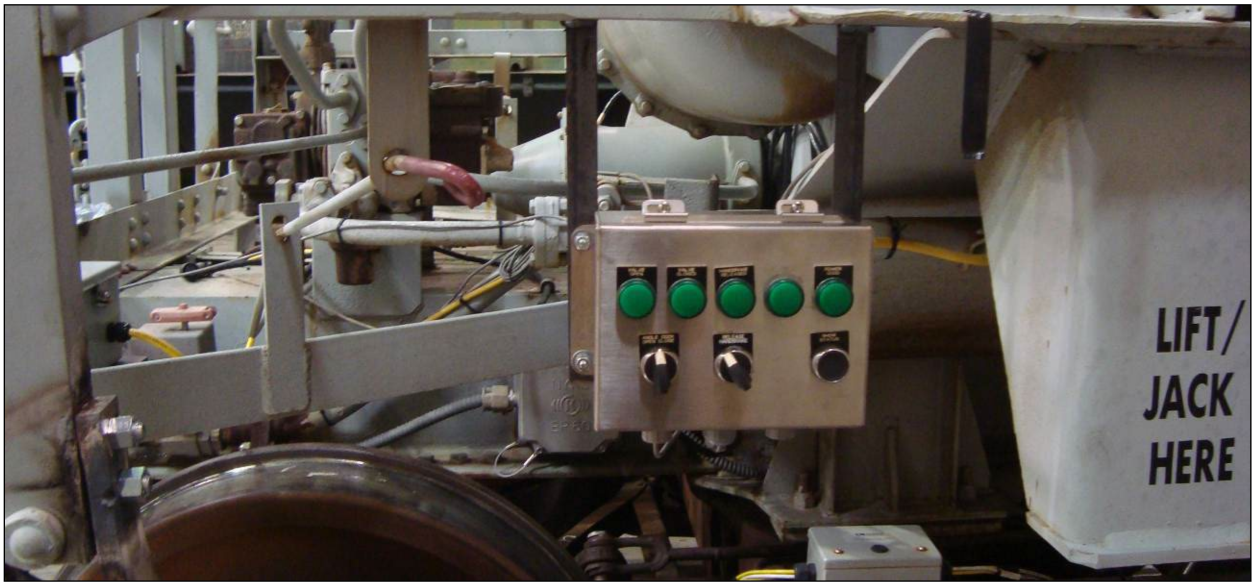

Figure 7. Side-Mounted Operation Box

3.3 Demonstration

The research team performed the demonstration of the EPSS on May 22, 2013. The procedure used for the demonstration was to connect all the EPSS connectors between each of the test cars, energize the system, take voltage and current readings at each of the junction boxes and battery boxes, and demonstrate the operation of select advanced devices. The advanced devices selected to be tested at each interval were an automated hand-brake release and an angle cock. Figure 8 shows measurements being taken at one of the junction boxes, and Figure 9 shows a measurement being taken at one of the battery boxes.

Figure 8. Junction Box Measurement

Figure 9. Battery Box Measurement

After the baseline measurements were taken, the test train was moved to the Transit Test Track, a 9.1 mile loop. After completing one full loop at 30 mph and one-half loop at 40 mph, measurements were taken of the voltage and current readings, and the angle cock and automated hand brake release were operated. The test train then completed another 1.5 laps at 40 mph, and final measurements were made. The final measurements taken were voltage and current readings, and the angle cock and automated hand brake release were operated.

4. Conclusions

SA designed and produced a freight car EPSS. From October 2012 to April 2013, FRA tasked TTCI to perform evaluation tests on SA's tri-couplers. TTCI also provided support for the installation and demonstration of the freight car EPSS. The tri-coupler evaluation test and EPSS demonstration included the installation of components used for testing and the trackworthiness testing of the components.

The tri-couplers various test results could be summarized as follows:

The twist and roll test showed that L/V criterion was exceeded on a run at 40 mph.

The pitch and bounce test showed that L/V criterion was exceeded on a run at 50 mph. Performing the fourth test run verified that the L/V criterion was exceeded during the pitch and bounce track section and was not caused during the transition between the twist and roll and the pitch and bounce track sections.

The Hunting test showed the acceleration criterion for the new limit exceeded 50 and 55 mph for the older limit.

The yaw and sway test showed the acceleration criterion for the new limit exceeded 45 and 50 mph for the older limit.

Impact testing of the tri-couplers was also conducted and verified that the tri-couplers could survive impacts that might be encountered during revenue service. Impacts such as those encountered during train make-up or humping operations were also simulated.

5. References

1. Association of American Railroads (April 2007). *Manual of Standards and Recommended Practices*, Design, Fabrication, and Construction of Freight Cars, M-1001 Chapter 11, Service-Worthiness Tests and Analyses for New Freight Cars. Washington, DC.

Abbreviations and Acronyms

ACRONYM	DEFINITION
EPSS	Electrical Power Supply System
FRA	Federal Railroad Administration
L/V	Longitudinal Force to Vertical Force Ratio
MSRP	Manual of Standards and Recommended Practices
SA	Sharma & Associates, Inc.
TTCI	Transportation Technology Center, Inc.
UP	Union Pacific