U.S. Department
of Transportation
**Federal Railroad
Administration**

Peacekeeper Rail Garrison Triplet Cars Track Worthiness Tests

Office of Research and
Development
Washington, DC 20590

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16. Abstract

Track worthiness tests were performed on a consist of three commercial depressed center flatcars (Triplet Cars) equipped with span bolsters to distribute heavy loads over four trucks. Tests were compared to, but not limited by, specifications in Chapter XI of the AAR's, *Manual of Standards and Recommended Practices*. The Triplet Cars track wothiness tests were perfomed to investigate the coupled car performance of span bolster cars before the individual Peacekeeper Rail Garrison (PKRG) span bolster cars were assembled in a train. Two of the Triplet Cars had trucks with 36-inch wheelsets similar to the PKRG security car and launch control car. The third car had trucks with 38-inch wheelsets similar to those used in the PKRG Missile Launch Car.

A second phase of testing was performed using the two Triplet Cars with 36-inch wheel sets and the Missile Launch Car (MLC), EMS-1.

During Phase I testing, all Triplet Cars performed within Chapter XI limits in the Pitch and Bounce Test, Twist and Roll Test, and the Yaw and Sway Test. The leading car exceeded Chapter XI criteria during hunting. The leading and trailing cars exceeded Chapter XI criteria during dynamic curving. All cars passed constant curving in the 7.5-degree curve and the 12-degree steady state curving, but the leading car exceeded Chapter XI criteria in the curve entry, and the trailing car exceeded criteria in the curve exit. No suspension separation, wheel lift, or permanent deformation of the car body was observed during the Curve Stability Test.

During Phase II testing, the Triplet Cars (leading and trailing) and the MLC performed within Chapter XI limits in the Pitch and Bounce Test, Twist and Roll Test, Yaw and Sway Test, and the Dynamic Curving Test. The three cars showed no sign of lateral instability during the Hunting Test. All cars passed constant curving in the 7.5- and 12-degree curve, but the trailing Triplet Car exceeded criteria in the 12-degree curve exit.

17. Key Words

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EXECUTIVE SUMMARY

The Transportation Test Center (TTC) performed vehicle dynamics tests for the Federal Railroad Administration (FRA) to investigate coupled car performance for span bolster equipped freight cars. This test of three commercially available span bolster cars (Triplet Cars), and an additional test in which the middle span bolster car was replaced with a mass simulated Missile Launch Car (MLC), were to provide a link between individual car performance and coupled car performance prior to the coupling of span bolster Peacekeeper Rail Garrison (PKRG) cars to make up the PKRG train. Comparing performance of the Triplet Cars to criteria set forth in Chapter XI of the Association of American Railroads (AAR) *Manual of Standards and Recommended Practices* showed that coupled span bolster car performance was not worse than that measured during single car testing of span bolster cars. This result is valid for trains of similar weight and length to the PKRG train only. Longer and heavier trains may induce in-train forces which are unfavorable to coupled span bolster car performance.

The commercial span bolster cars exceeded some Chapter XI criteria in curving and in curve entry and exit performance. Similar results were noted in single car testing of PKRG span bolster equipment. The Mass Simulated MLC did not exceed criteria during this testing.

The FRA requested Triplet Cars track worthiness testing to be completed in two phases. Phase I was conducted with the three Triplet Cars, and Phase II was conducted with two of the previously tested Triplet Cars and the PKRG MLC. The Triplet Cars consisted of two Atchison, Topeka and Santa Fe (ATSF) depressed center flatcars with 36-inch wheel sets, and one ATSF depressed center flatcar with 38-inch wheel sets. The wheelsets were mounted in freight trucks very similar to those used for PKRG span bolster cars. The cars were loaded to simulate specific PKRG car weights.

Track worthiness testing was performed to document on-the-rail dynamic performance of coupled span bolster cars and to provide input data for the Train Dynamics Model (TDM) vehicle performance simulator. Phase I and II testing was performed on smooth tangent and curved track, on tangent track with vertical and lateral misalignments, and on curved track with cross level and gage deviations.

Phase I testing of the Triplet Cars on tangent track with vertical and lateral perturbations designed to excite vehicle modes of pitch and bounce, twist and roll, and yaw and sway produced results that fell within Chapter XI criteria. Lateral instability of the middle and trailing car was noted at speeds over 60 mph. Dynamic curving tests with vertical and gage deviations, produced results outside the Chapter XI criteria for the leading and trailing car. The leading and trailing cars also had difficulty negotiating curve entry and exit spirals on a 12-degree curve. Constant curving performance was within Chapter XI criteria.

Phase II testing with the leading and trailing Triplet Cars on either side of the MLC showed acceptable performance for all tests with the exception of the 12 degree curve exit. Phase II tangent track testing was limited to speeds of 60 mph or less at the Air Force's request.

Coupled span bolster car performance, with the relatively short simulated PKRG train, closely followed performance measured during single car testing of the PKRG span bolster cars.

Table of Contents

Tables

Table of Figures

1.0 INTRODUCTION

The Association of American Railroads (AAR), Transportation Test Center (TTC), Pueblo, Colorado, has contracted with the Federal Railroad Administration (FRA) to perform vehicle performance tests on the Peacekeeper Rail Garrison (PKRG) rail cars according to specifications in Chapter XI, AAR's, M-1001, *Manual of Standards and Recommended Practices*.

These tests include static and quasi-static truck characterization, vehicle dynamic characterization, service worthiness testing, and track worthiness testing.

The Chapter XI individual car test series was performed for the PKRG Fuel Car (FC), Launch Control Car (LCC), Missile Launch Car (MLC), and Maintenance Car (MC). The MLC and LCC have span bolster trucks designed to spread the car weight over four conventional 3-piece truck suspensions. When the PKRG train is assembled several span bolster cars will be coupled together. It was determined by the Air Force that a preliminary test to investigate coupled span bolster car performance would be prudent.

Three commercially available span bolster cars, referred to as Triplet Cars, were obtained for this test. The coupled span bolster cars were tested using Chapter XI as the track worthiness test plan.

The service worthiness testing of the Triplet Cars consisted only of the curve stability test. Curve stability was performed to test the cars' tendency to experience wheel lift or suspension separation under the influence of longitudinal forces in a 10 degree curve.

Phases I and II of the Triplet testing preceded testing of the actual Rail Garrison cars as a train. Phase I tests were performed with the Triplet Cars to document the performance of coupled span bolster cars and to provide validation data for AAR's Train Dynamics Model (TDM). The Triplet consist was comprised of two Atchison, Topeka and Santa Fe depressed center flatcars with 36-inch wheel sets loaded at 400,000 pounds (ATSF 90006, ATSF 90007) and an Atchison, Topeka and Santa Fe depressed center flatcar with 38-inch wheel sets (ATSF 90004) loaded at 560,000 pounds. All three cars were eight axle span bolster cars loaded with concrete blocks.

Phase II tests were performed with the same two 36-inch wheel set Triplet Cars and the Missile Launch Car (MLC EMS-1). The MLC, EMS-1 replaced the ATSF 90004 as the middle car.

Prior to the track worthiness portion of the Triplet test, a separate test was conducted at the request of the United States Air Force (USAF) through FRA. The heaviest car, ATSF 90004, was tested over the dynamic curving section by itself (Extra Dynamic Curving Test). Results from this test are presented in the FRA "Quick Look" report entitled "Extra Dynamic Curving Test on ATSF 90004 Depressed Center Flatcar."

After performance of coupled span bolster cars was demonstrated in service worthiness and track worthiness tests, and the TDM was validated against those cars, train performance predictions were to be made for the PKRG Train Test.

The vehicle characterization of the Triplet Cars is covered in a separate report entitled "Peacekeeper Rail Garrison Vehicle Characterization Test of Triplet Cars, ATSF 90004 and 90006."

This report, entitled "Triplet Cars Track Worthiness Final Report," finalizes the Triplet Phases I and II track worthiness tests.

2.0 SERVICE WORTHINESS/CURVE STABILITY OBJECTIVE

The objective of the Curve Stability Test was to verify that no wheel lift exceeding 1/8 inch or car body separation occurred while buff and draft loads of 200,000 pounds were applied.

3.0 SERVICE WORTHINESS/CURVE STABILITY PROCEDURES

Curve stability testing was performed on the 10-degree curve of the south wye of the Urban Rail Building access track. The curve has 1/2-inch maximum superelevation. The Triplet Cars were subjected to a buff load of 250,000 pounds and a draft load of 200,000 pounds sustained for a minimum of 20 seconds. Car body suspension separation and wheel lift was monitored. For the purpose of this test, wheel lift was defined as a separation of wheel and rail exceeding 1/8 inch when measured 2 5/8 inches from the rim face at the inside of curve for buff and outside for draft. The "Triplet Cars Service Worthiness Test Procedure" may be found in Appendix A.

4.0 PHASE I OBJECTIVE

The objective of track worthiness testing was to measure the on-the-rail dynamic performance of coupled span bolster cars as described by Chapter XI. The vehicle performance was to be evaluated for the following test conditions:

- Lateral Stability on Tangent Track (Hunting)
- Constant Curving
- Spiral Negotiation
- Twist and Roll
- Pitch and Bounce
- Dynamic Curving
- Yaw and Sway
- Turnout and Crossover

Vehicle performance was compared to, but not limited by, the criteria described in Table 11.1 of Chapter XI, which is attached as Appendix B.

5.0 PHASE I PROCEDURES

The location of each Track Worthiness Test zone is shown in Figure 5.1. Detailed "Triplet Track Worthiness Test Procedure" may be found in Appendix C (1).

The smooth tangent and curving tests are performed to document performance on nominal railroad tracks. The perturbed tracks are designed to excite important vehicle modes. This excitation is at 39-foot wavelengths because these are felt to be most common in operating service. Other wavelengths are possible, but less likely.

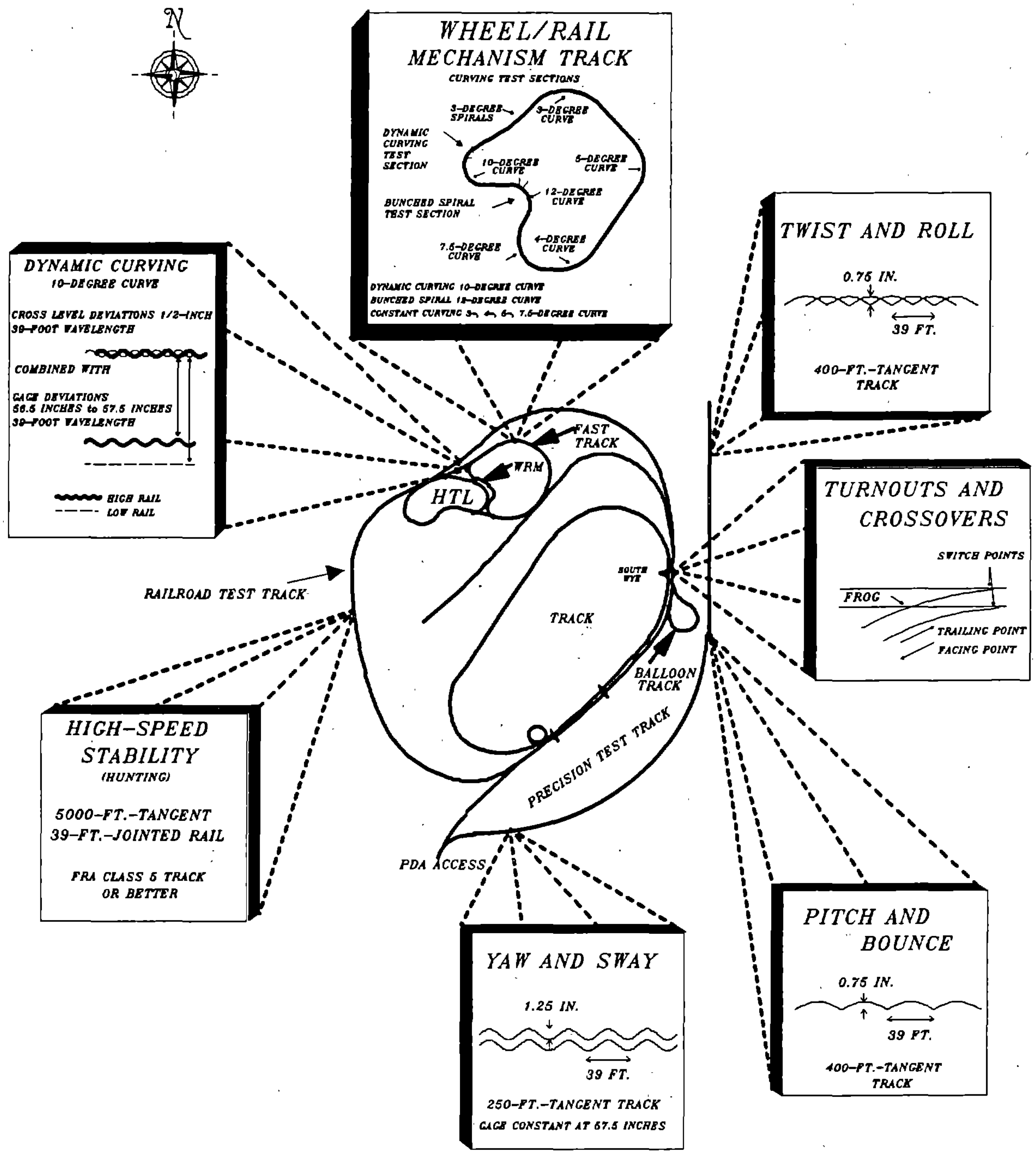

Figure 5.1 Chapter XI Track Worthiness Test Facilities

5.1 LATERAL STABILITY ON TANGENT TRACK (HUNTING)

Hunting was the first test performed. This test was conducted to confirm that hunting (lateral oscillating instability in the trucks) did not occur within the normal operating speeds of the car. Chapter XI criteria for this test is lateral car body acceleration (g) of 1.0 g peak-to-peak sustained for 20 seconds, or 1.5 g peak-to-peak single occurrence, or an axle sum L/V of 1.3 sustained for 50 milliseconds.

Procedures for the Hunting Test may be found in Section 11.5.2 of Chapter XI. This test was conducted on a 5,000-foot tangent section (between R38 and R33) of the Railroad Test Track (RTT). Test runs were performed at 30, 40, 50, 60 and 67 mph. All three Triplet Cars were pulled from the A-end. Four trailing fully loaded buffer cars were used primarily for braking as the Triplet Cars were equipped with instrumented wheel sets which cannot be exposed to braking. Figure 5.2 gives a description of the test track.

HIGH-SPEED
STABILITY
(HUNTING)

5000-FT.-TANGENT
39-FT.-JOINTED RAIL

FRA CLASS 5 TRACK
OR BETTER

Figure 5.2 Hunting Test Track

The test consist, (Figure 5.3), included one to two locomotives as required, the T-5 instrumentation car, the three loaded Triplet Cars, and three to six loaded buffer cars.

Instrumented wheel sets were placed at the leading axle of the trailing span bolster of the leading car, at the leading axle of each truck at the middle car, and at the leading axle of the leading span bolster of the trailing Triplet Car.

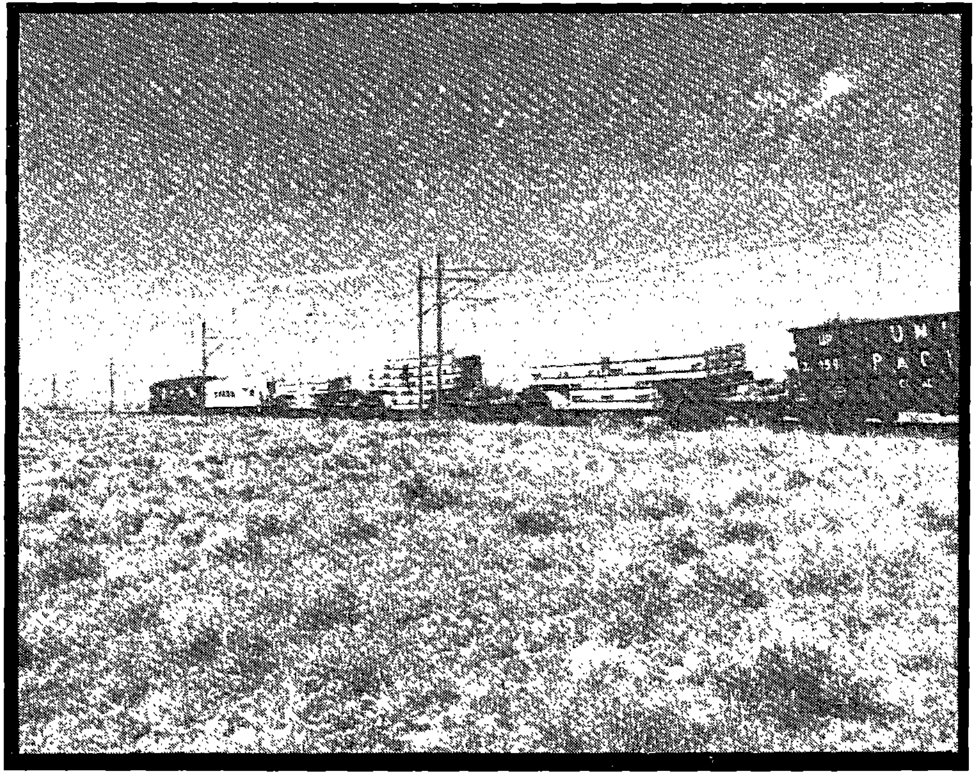

Figure 5.3 Test Consist

5.2 TWIST AND ROLL

Twist and roll testing was performed to determine the cars' ability to negotiate cross level perturbations. These perturbations were designed to excite the natural twist and roll motions of each car. Three Chapter XI criteria are given for this test: maximum roll angle of 6 degrees peak-to-peak, maximum axle sum L/V of 1.3 sustained for 50 milliseconds, and a minimum vertical wheel load of 10 percent of the static wheel load sustained for 50 milliseconds.

The Twist and Roll Test followed Section 11.6.2 of Chapter XI and was conducted on the Precision Test Track (PTT) at station 1646+10 to 1650+90. This section of the PTT was shimmed to represent staggered jointed rail with a maximum cross level deviation of 0.75 inches as shown in Figure 5.4.

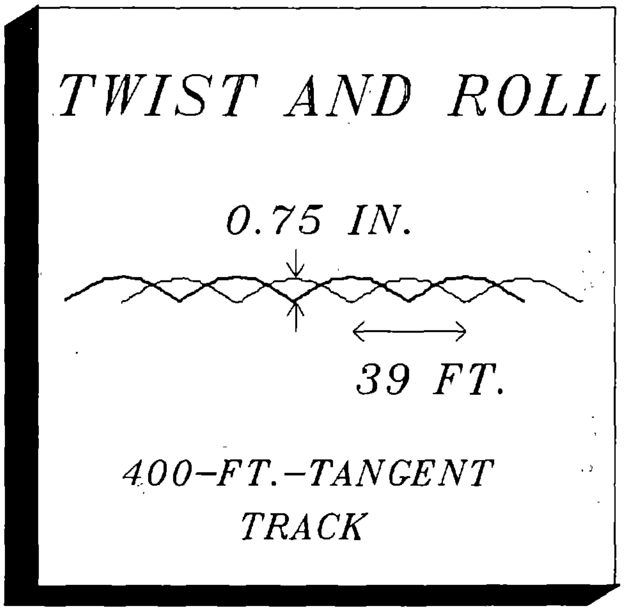

Figure 5.4 Twist and Roll Test Zone

5.3 PITCH AND BOUNCE

The Pitch and Bounce Test determines the dynamic pitch and bounce response of each car as it is excited by inphase vertical inputs from the track. Track, which generates this type of input, may be found at bridges, road crossings, and where there is a change in the underlying vertical support structure to the track. This phenomenon can also occur when rail joints are exactly in-phase on both rails. The results were compared to the Chapter XI limitations. The Triplet Cars were tested in the loaded condition with four buffer cars.

The Pitch and Bounce Test was conducted on the PTT and followed the procedure listed in Chapter XI Section 11.6.3. The test section was located between stations 1716+00 to 1720+00 and was shimmed to represent parallel jointed rail with a 0.75-inch amplitude perturbation at 39-foot intervals, as shown in Figure 5.5.

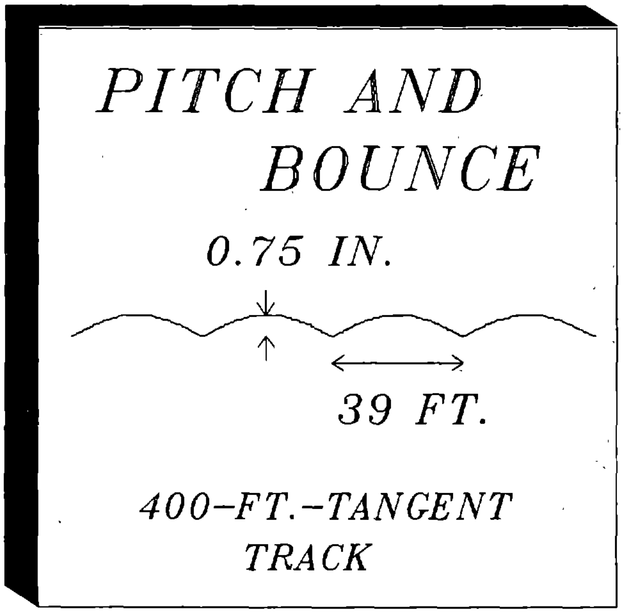

Figure 5.5 Pitch and Bounce

5.4 DYNAMIC CURVING

The Dynamic Curving Test determines the cars' ability to negotiate curved track with simultaneous cross level (vertical) and gage (lateral) misalignments. Results from this test were compared to the following four Chapter XI performance criteria: (1) maximum ratio of wheel lateral force divided by the vertical force (L/V) of 0.8, (2) maximum axle sum L/V of 1.3, (3) maximum roll angle of 6 degrees peak-to-peak, and (4) minimum vertical wheel load of 10 percent of the static wheel load. The 50 millisecond rule applied to all but the roll angle.

The Dynamic Curving Test was conducted on the 10-degree curve (station 1+00 to 3+50) of the Wheel/Rail Mechanism (WRM) track in accordance with Section 11.6.5 of Chapter XI. The 10-degree curve was shimmed to provide a cross level of 0.5 inches combined with lateral perturbations giving a maximum gage of 57.5 inches and a minimum gage of 56.5 inches (Figure 5.6). Test runs were performed in the clockwise and counter-clockwise directions.

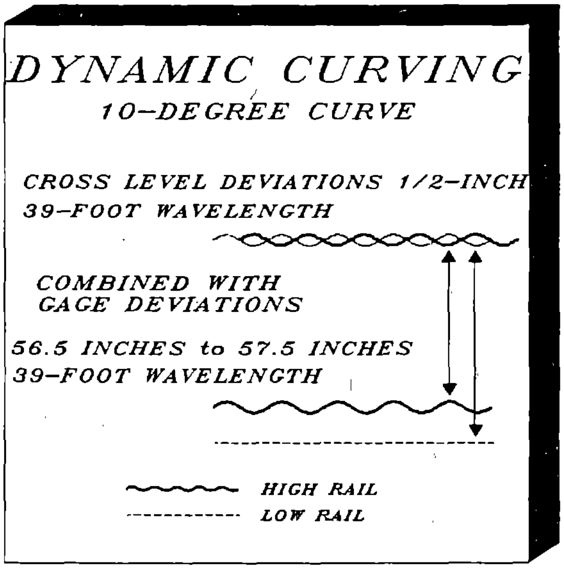

Figure 5.6 Dynamic Curving Test Track

5.5 CONSTANT CURVING

The Constant Curving Test was conducted on the WRM track (Figure 5.7). This test utilized the 7.5-degree curve and the 12-degree curve with a bunched spiral. The procedure for the Constant Curving Test is found in Chapter XI Section 11.5.3.

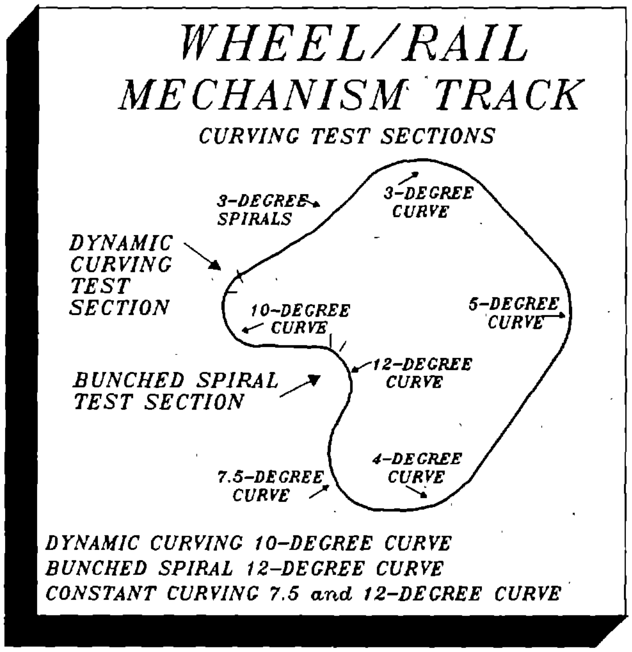

Figure 5.7 Constant Curving Test Track

The Constant Curving Test determines the cars' ability to negotiate normal track curves. Chapter XI criteria to compare to was a maximum 95th percentile wheel or axle L/V. This test was performed to verify that the cars did not have wheel climb potential or impart large lateral forces to the rails during curving. Test runs were performed at balance speed, 3 inches underbalance, and 3 inches overbalance. Speeds were calculated with the following formula:

$$V = \sqrt{1480 \quad \frac{(U+H)}{D}}$$

Where:

U = underbalance in inches
H = superelevation in inches
D = degree of curvature
V = speed in mph.

In some cases the track speed limit was lower than the calculated +3-inch speed. The track speed limit was used for +3 inches in that case. In other cases the calculated -3 inches speed was zero or less. In those cases a lower speed was calculated:

$$V^{*}_{-3} = V_0 - (V_{+3} - V_0)$$

Where:

V^{*}_{-3} = speed at 3 inches underbalance
V_0 = balance speed in mph
V_{+3} =speed at 3 inches overbalance.

Table 5.1 Shows a tabulation of speeds for each curve. All calculated speeds were rounded to 1 mph. Each test speed was performed in both clockwise and counterclockwise directions.

Table 5.1 Curve Speeds

CURVE DEGREE	SUPER ELEVATION (inches)	BALANCE SPEED (mph)	+3 INCH SPEED (mph)	-3 INCH SPEED (mph)
7.5	3	24	31	14*
12	5	24	32**	16

*** Calculated Nominal Speed**
**** Maximum Track Speed**

5.6 SPIRAL NEGOTIATION AND WHEEL UNLOADING

The Spiral Negotiation and Wheel Unloading Test was performed in conjunction with the Constant Curving Test. A spiral is the transition from a curve to a tangent track, in which the change of degree of curvature and the change in rail to rail elevation is constant throughout its length. The purpose of the exaggerated bunched spiral test was to twist the trucks and the car body. Chapter XI states that the minimum acceptable vertical wheel load is 10 percent of the static wheel load and that the maximum wheel L/V is 0.8. Entry and exit spirals were monitored during constant curving runs on the 7.5 and 12 degree curve. The 7.5 degree curve has 200-foot long conventional spirals. One spiral in the 12 degree curve is a 200-foot long conventional spiral, the other is a 200 feet long spiral with all 5 inches of elevation change concentrated in the middle 100 feet. As with constant curving, spiral negotiation was run in both clockwise and counterclockwise directions. All entrance and exit spirals, including the bunched spiral, were analyzed although Chapter XI only specifies the bunched spiral.

5.7 YAW AND SWAY

The Yaw and Sway Test was conducted to determine the cars' ability to negotiate laterally misaligned track, which would excite the cars in a yaw and sway motion. Two Chapter XI criteria are given for this test: maximum truck side L/V of 0.6 sustained for 6 feet, and a maximum axle sum L/V of 1.3 sustained for 50 milliseconds.

To obtain truck side L/V readings, both axles under one truck needed to be instrumented to measure wheel/rail forces. Therefore, instrumented wheel sets were installed at both axle locations under the leading truck of the leading span bolster and under the trailing truck of the trailing span bolster of the middle Triplet Car. Figure 5.8 shows instrumented wheel set placement for Phase I yaw and sway testing. A shortage of 36-inch instrumented wheel sets prevented implementation of this configuration for the leading and trailing Triplet Cars.

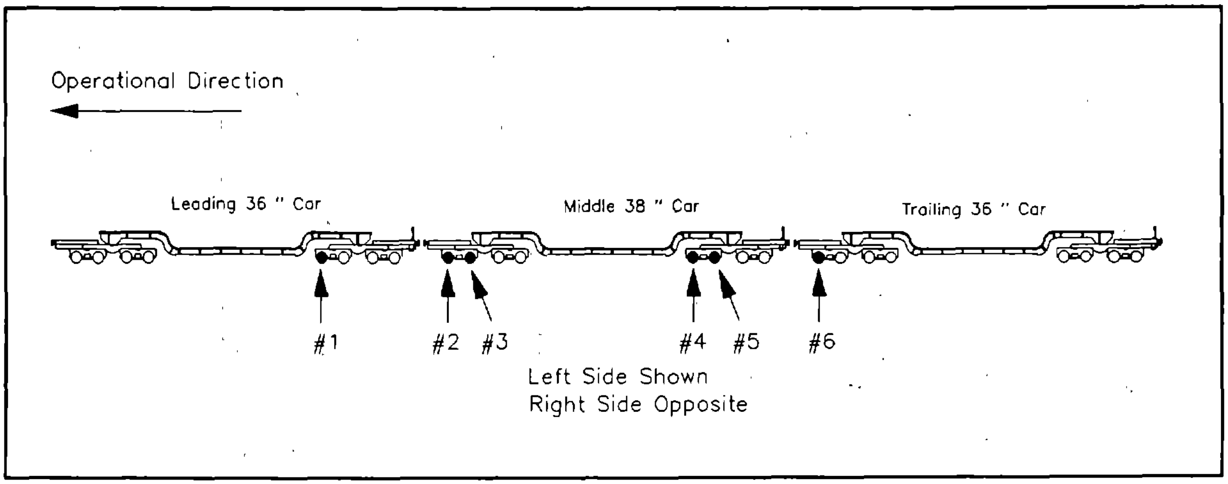

Figure 5.8 Instrumented Wheel Set Placement for Yaw and Sway

The Yaw and Sway Test was conducted in accordance with Section 11.6.4 of Chapter XI. Station 21+00 to 26+00 of the PTT was the site for this test. This section had sinusiodal lateral track alignment deviations of wavelength 39 feet and amplitudes of 1.0 inches peak-to-peak on both rails at a constant wide gage of 57.5 inches. These perturbation amplitudes were less than the Chapter XI specified 1.25 inches. Figure 5.9 shows the test zone as specified by Chapter XI with 1.25-inch perturbations.

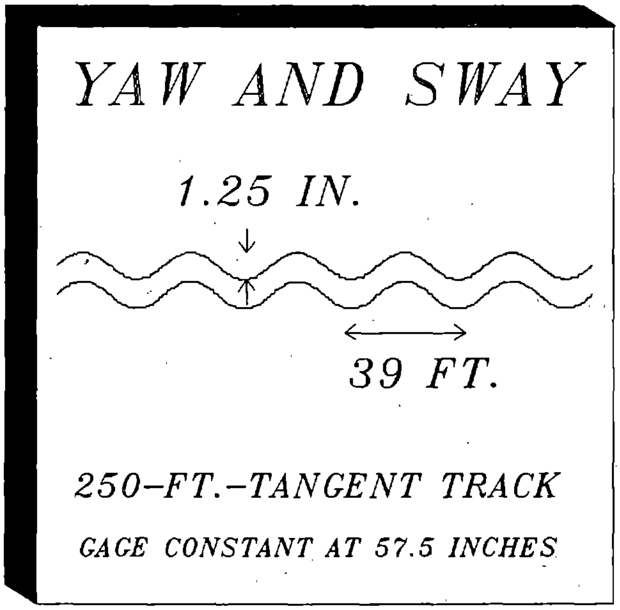

Figure 5.9 Yaw and Sway Test Track

Test speeds were 10 to 60 mph in 5 mph increments. Speeds of 25, 30, and 55 mph were run twice to verify data. An additional speed of 57 mph was run as a safety measure before proceeding to 60 mph.

5.8 TURNOUT AND CROSSOVER

Turnout and crossover tests were conducted to determine if the cars were able to negotiate standard turnouts and crossovers with a margin of safety in wheel/rail forces. A turnout is an arrangement of a switch and a frog with closure rails, by which cars may be diverted from one track to another. A crossover is an arrangement of two turnouts with the track between the frogs arranged to allow passage between two parallel tracks. The wheel/rail forces would indicate if there was a tendency for wheel climb or to induce large lateral forces into the track.

The Turnout and Crossover Test is not listed in Chapter XI as an official test but was conducted to verify the operation of the vehicle through crossovers and turnouts. The crossover from the Heavy Tonnage Loop (HTL) to the RTT (Switch NO. 307A & 307B) was used for crossover testing. This is a No. 10 crossover with a 20 mph speed restriction. Crossover test runs were performed at 10, 17 and 20 mph. Figure 5.10 illustrates a typical crossover.

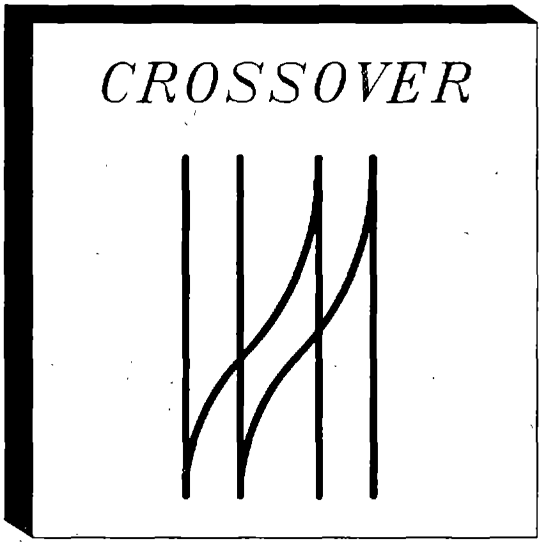

Figure 5.10 Crossover

Turnout testing utilized the turnout entering and exiting the Urban Rail Building (URB) switch No. 704. This is a No. 8 turnout with a 15 mph speed restriction. Turnout test runs were performed at 10 and 15 mph. Figure 5.11 illustrates a typical turnout.

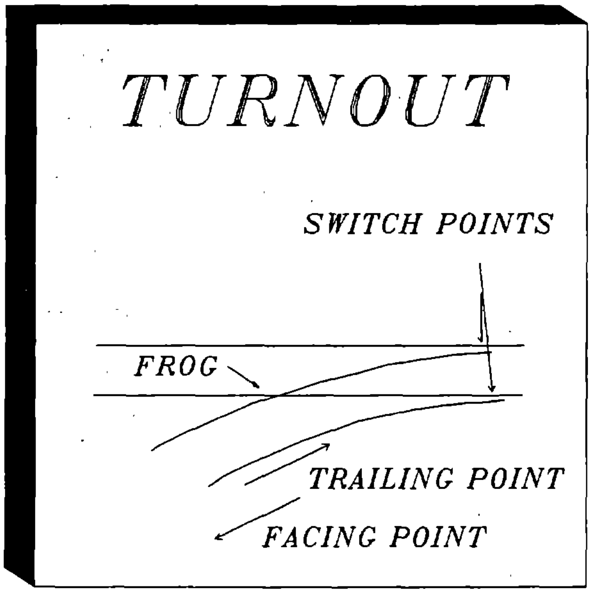

Figure 5.11 Turnout

6.0 PHASE II OBJECTIVE

The objective of Phase II track worthiness testing was to measure the on-the-rail dynamic performance of the MLC, EMS-1 in a coupled span bolster configuration. Vehicle performance was monitored for the following Chapter XI test conditions:

- Lateral Stability on Tangent Track (Hunting)
- Constant Curving
- Spiral Negotiation
- Twist and Roll
- Pitch and Bounce
- Dynamic Curving
- Yaw and Sway
- Turnout and Crossover

Vehicle performance was compared to the criteria described in Table 11.1 of Chapter XI, which is attached as Appendix B.

7.0 PHASE II PROCEDURES

The location of each track worthiness tests zone was shown in Figure 3.1. Detailed Triplet Phase II Track Worthiness Test Procedures may be found in Appendix C (3). All Phase II tests used identical procedures as Phase I tests. The Phase II test consist is shown in Figure 7.1. The MLC was tested B-end leading. The maximum test speed for Phase II tests was 60 mph. Individual test speeds may vary between Phase I and Phase II.

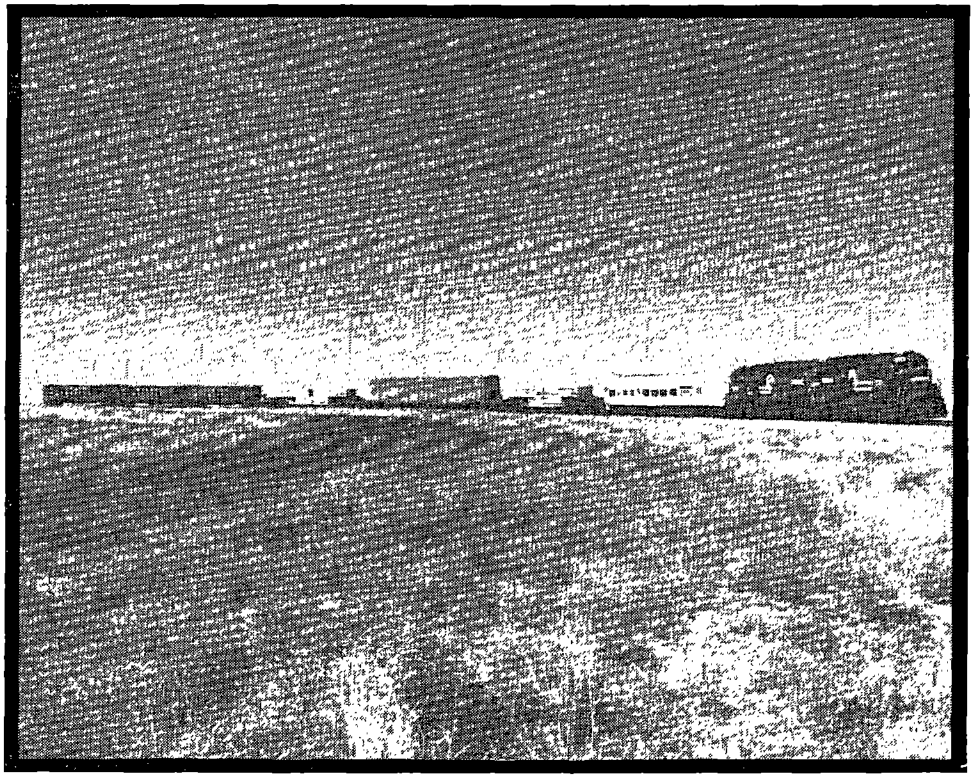

Figure 7.1 Phase II Test Consist

8.0 MATERIALS AND INSTRUMENTATION

8.1 ATCHISON, TOPEKA AND SANTA FE 90006

One of the three test vehicles was the ATSF 90006 depressed center flatcar, shown in Figure 8.1.

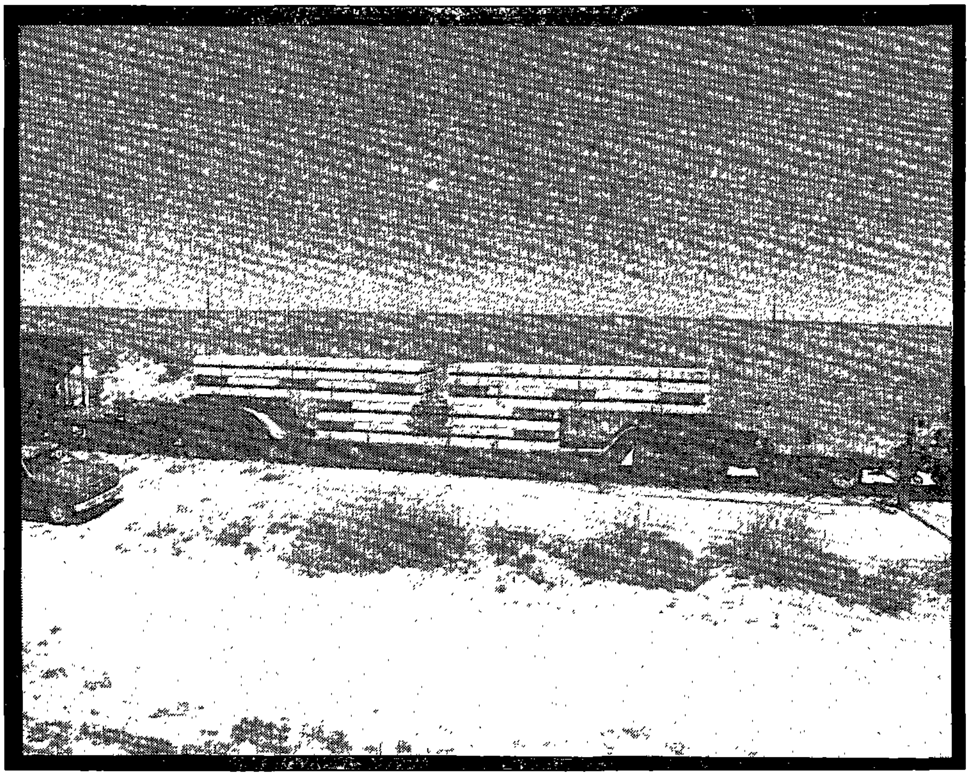

Figure 8.1 ATSF 90006 (Loaded Condition)

The ATSF 90006 depressed center flatcar was chosen for its ability to be loaded to simulate the USAF's PKRG Launch Control Car (LCC) designed by Rockwell International. The overall length was 2 feet shorter and less than a foot narrower than the LCC.

Rockwell International estimates the weight of the LCC at 404,150 pounds. The ATSF 90006 test car was loaded with twelve 22,000-pound concrete blocks for a total car weight of 404,550 pounds. The center of gravity for the car and load was 68.1 inches. The mass moment of inertia in the X direction was approximately 2.1 x 10^6 in-lbs-sec^2, and in the Y direction 4.9 x 10^7 in-lbs-sec^2. ATSF 90006 was equipped with span bolsters to distribute heavy loads over four 100-ton design trucks, two at each end.

Contact between the car body and the span bolster was at the center plate which was 20 inches in diameter and used a center pin. Solid plate non-contacting side bearings were also used between the car body and span bolster. Four American Steel Foundries' (ASF) 100-ton design ride control trucks were utilized, two in each span bolster. No primary suspension was present. The secondary suspension consisted of seven outer and five inner D-3 springs. The spring configuration is shown in Figure 8.2.

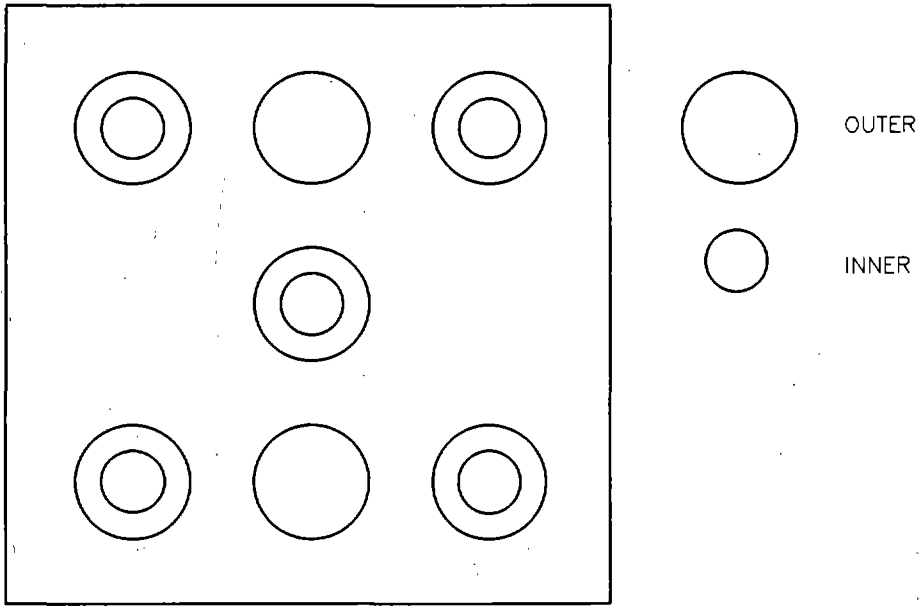

Figure 8.2 ATSF 90006 Spring Configuration

The 36-inch wheels were used in the same condition they arrived. No additional profiling was performed.

The axle spacing within each 100-ton design truck was 70 inches. The truck center spacing within a span bolster was 140 inches. The span bolster center spacing was 60 feet. The car body was 86 feet 1 inch long with a 32-foot long depressed center. The car length was 91 feet over strikers. Type E-60 tight lock couplers with 15-inch Freightmaster M-E cushioning devices were used.

8.2 ATCHISON, TOPEKA AND SANTA FE 90007

The ATSF 90007 depressed center flatcar was chosen for its ability to be loaded to simulate the Air Force's PKRG Security Car (SC) designed by Rockwell International. The overall length was 2 feet shorter and less than a foot narrower than the SC.

The weight of the SC, as weighed at the TTC, was 410,550 pounds. All attributes of the ATSF 90007 are identical to that of the ATSF 90006.

8.3 ATCHISON, TOPEKA AND SANTA FE 90004

The ATSF 90004 depressed center flatcar, with 38-inch wheel sets is shown in Figure 8.3.

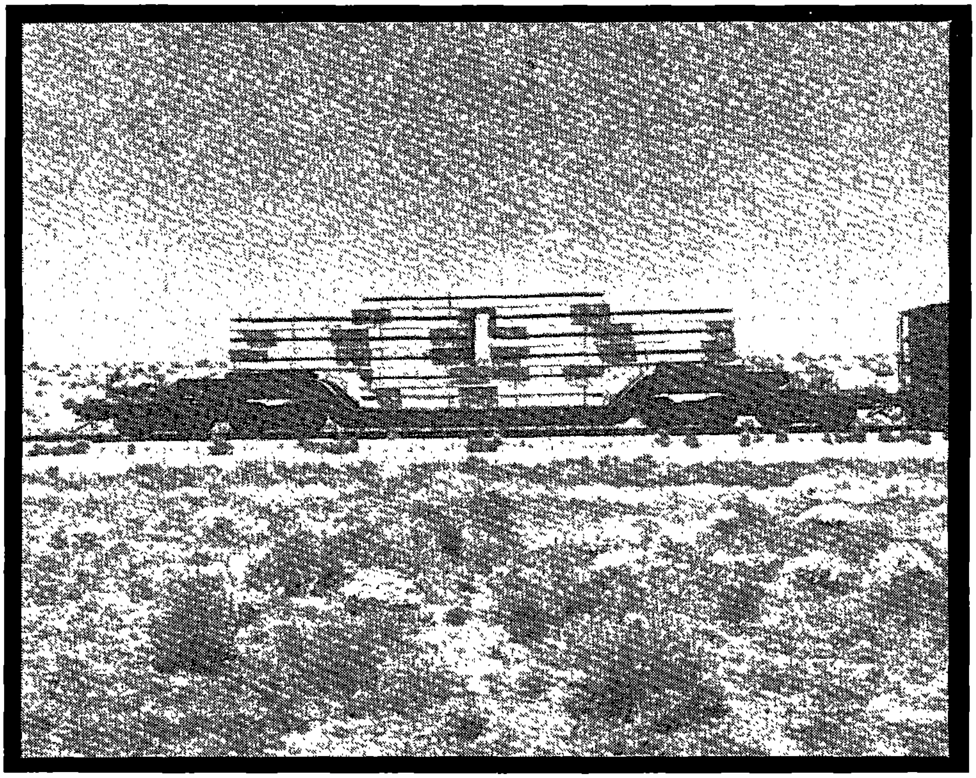

Figure 8.3 ATSF 90004 (Loaded Condition)

The ATSF 90004 depressed center flatcar was chosen for its ability to be loaded to simulate the USAF's PKRG Missile Launch Car (MLC) EMS-1, designed by Westinghouse Electric Corporation (WEC). The overall length was 5 feet 6 inches shorter than the MLC. The width was approximately the same.

The weight of the MLC, EMS-1, as weighed at the TTC, was 558,150 pounds. The ATSF 90004 car was loaded with eighteen 22,000 pound concrete blocks for a total car weight of 556,900 pounds. The center of gravity for the car and load was 87.1 inches. The mass moment of inertia in the X direction was approximately 2.9×10^6 in-lbs-sec^2, and in the Y direction 5.3×10^7 in-lbs-sec^2. ATSF 90004 was designed with a span bolster to distribute heavy loads over four 125-ton design trucks, two at each end. Contact between the car and the span bolster was at the center plate which was 22 inches in diameter, and used a center pin. Solid plate non-contacting side bearings were used between the car body and span bolster. Single roller bearings were used between the span bolster and trucks. There was no primary suspension. The secondary suspension system consisted of eight outer and eight inner D-3 springs.

The 38-inch wheels were used in the same condition they arrived. No additional profiling was performed. The axle spacing within each 125-ton design truck was 72 inches. The truck center spacing within a span bolster was 144 inches. The span bolster center spacing was 55 feet. The car body was 62 feet long with a 25-foot long depressed center. The car length was 86 feet 4 inches over pulling face of couplers. Type E-60 tight lock couplers with a 15-inch Freightmaster M-E cushioning device was used.

8.4 MISSILE LAUNCH CAR (MLC) EMS-1

The PKRG Missile Launch Car, Engineering Mass Simulator, Car WECX1003R is shown in the loaded condition in Figure 8.4.

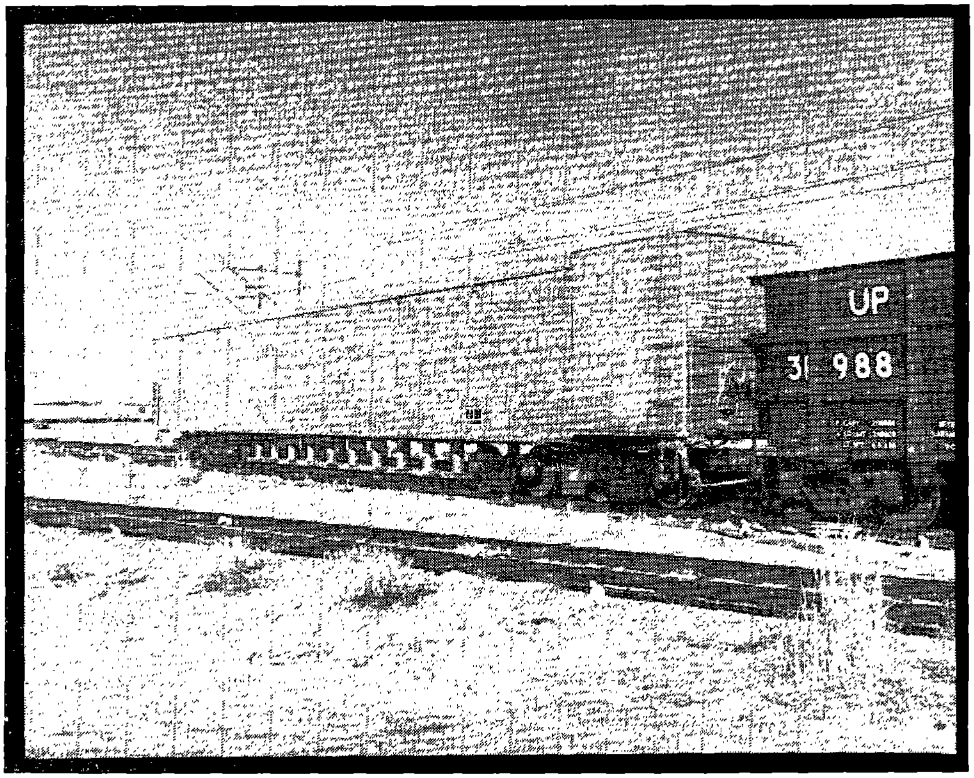

Figure 8.4 Missile Launch Car EMS-1 (Loaded Condition)

The car was designed for the USAF by WEC to carry a Peacekeeper Canisterized Missile and associated launch hardware. The missile and canister were simulated with concrete blocks in a steel truss.

The car was not longitudinally symmetric. The operational support equipment (OSE) bay was bolted to the B-end of the car. That bay would hold the launch hardware and environmental control system. Those items were simulated with steel plates on the outside walls of the OSE bay. While the mass and center of gravity of the EMS-1 car may have been similar to an operational model (OM), the polar moments of inertia were not necessarily the same.

WEC estimated the weight of the loaded MLC at 554,000 pounds. The weight of the MLC, EMS-1, as weighed at the TTC, was 558,150 pounds. Span bolsters were required to distribute the load over four trucks, two at each end. The span bolsters were designed by and constructed for WEC.

Four 125-ton design ride control trucks were utilized, two in each span bolster. The primary suspension consisted of small plastic disks (TecsPads) between the side frames and the bearing adapters. The secondary suspension system consisted of five inner and nine outer D-7 springs.

The axle spacing within each 125-ton design truck was 72 inches. The truck center spacing within a span bolster was 144 inches. The overall length was 91 feet 7 inches. The width was approximately 11 feet.

8.5 INSTRUMENTED WHEEL SETS

Four 38-inch and four 36-inch instrumented wheel sets were provided to the TTC for this test as Government Furnished Equipment (GFE). Two sets were manufactured by the Illinois Institute of Technology Research Institute (IITRI), and two sets were manufactured by ENSCO Inc. The instrumented wheel sets used standard wheels and axles machined smooth and strain gaged. Vertical and lateral wheel force, and axle torque were calculated from the strain gage output.

8.5.1 IITRI Instrumented Wheel sets

Each wheel had six strain gage bridges. Three strain gage bridges were used to measure vertical force, two were used to measure lateral force and one was used to indicate lateral wheel tread position on the rail. Axle torque was measured with a strain gage bridge on the axle. The raw analog strain gage signals were acquired with IITRI's 386 based computer system and an analog to digital (AD) converter. The signals were processed to produce digital output in the form of left and right side vertical wheel force, lateral wheel force, and axle torque. The digital signals were then converted to analog. Those analog signals were displayed on strip charts during testing and acquired on the Hewlett-Packard (HP) Data Acquisition System (DAS) with the output from other transducers. Appendix D (1 and 2) contains the "IITRI Wheel Set Instrumentation, Calibration, and Oprerational Procedures."

8.5.2 ENSCO Instrumented Wheel sets

The ENSCO wheel sets were similar in design to the IITRI. One major difference was the wheel rotational position sensor. Rotational position on the IITRI wheels is implied from vertical gage output. The ENSCO wheel sets used magnetic switches between the axle and bearing adapter to monitor wheel rotation. ENSCO used two vertical gage bridges, two lateral gage bridges, but no lateral position gage. ENSCO used a bridge on the axle to measure torque. Signal processing was similar to IITRI; however, ENSCO used a 286 based computer. Appendix E is the Triplet Cars "ENSCO Wheel Set Instrumentation, Calibration, and Operation Procedure."

8.6 ROLL GYROMETERS

Chapter XI requires the measurement of car body roll angle. To compare car performance to Chapter XI, four roll rate gyrometers (gyros) were installed. One roll rate gyro was installed on the A-end of the leading Triplet Car, one gyro was installed on each end of the middle car during Phase I and Phase II, and one on the B-end of the trailing Triplet Car. All gyros were installed at floor level above the span bolster center bowl.

The output signal was a roll rate. This was electronically integrated and output to the DAS as an analog roll angle.

8.7 LATERAL ACCELEROMETERS

Endevco 25 g accelerometers were installed laterally at the A- and B-ends on the roll gyro base plates. They were utilized for the hunting test criterion of 1.0 g peak-to-peak sustained for 20 seconds.

8.8 ADDITIONAL MEASUREMENTS

Vertically and longitudinally oriented accelerometers were installed on the cars at the Air Force's request. Coupler angle in relation to span bolster and car body was also taken on the A-end of the middle Triplet Car. Two instrumented couplers were installed on the

8.9 DATA ACQUISITION SYSTEM (DAS)

Analog signals from 160 signal conditioners were multiplexed and digitized with a HP-6944 multiprogrammer. Digital signals were acquired with a HP-360 computer. AD counts were stored with their proper engineering unit conversions on one file. Data files were stored on a 650 megabyte optical disk.

8.10 CHART RECORDERS

Processed instrumented wheel set information was displayed real time on six chart recorders. Roll angle, lateral acceleration and coupler loads were also displayed real time on the recorders.

9.0 SERVICE WORTHINESS/CURVE STABILITY RESULTS

No car body suspension separation or wheel lift occurred on any Triplet Car during the Curve Stability Test.

10.0 PHASE I TEST RESULTS

Pre-test predictions were made for Phase I curving. The predictions were made using a modified version of the NUCARS (New and Untried Car Analytic Regime Simulation) vehicle dynamics program. The modifications were among those made to the original code as part of the TDM development effort. Appropriate predictions are noted in each subsection. Predictions were made for the FRA at the USAF's request. Chapter XI criteria were used as a guideline to measure the performance of coupled span bolster cars and to indicate safe conduct of each test. Vehicle performance was compared to, but not limited by, Chapter XI criteria.

10.1 HUNTING

There were two limiting criteria for the Hunting Test: (1) maximum axle sum L/V of 1.3 sustained for 50 milliseconds, and (2) maximum peak-to-peak lateral acceleration of 1.0 g sustained for 20 seconds, or any occurrence greater than 1.5 g. The maximum test speed was 67 mph.

Table 10.1 is a tabulation of hunting test results for the leading, middle, and trailing Triplet Cars.

Table 10.1 Hunting Test Results

SPEED (mph)	MAX P-P LAT ACCEL (g)	MAXIMUM AXLE SUM L/V
LEADING TRIPLET CAR (ATSF 90006)		
40	.76	.45
50	.62	.58
60	1.23	.57
65	1.38	.88
67	1.45	.99
MIDDLE TRIPLET CAR (ATSF 90004)		
40	.79	.45
50	.84	.45
60	1.45	.95
65	1.52	.94
67	1.54	1.16
TRAILING TRIPLET CAR (ATSF 90007)		
40	.31	.45
50	.46	.45
60	.87	.42
65	.99	.52
67	1.52	.84

The maximum lateral peak-to-peak car body acceleration was 1.54 g, which occurred on the middle car at 67 mph. A 1.52 g lateral acceleration was recorded on the trailing car at 67 mph. Both these values exceed Chapter XI criteria, which states that no occurrences of 1.5 g peak-to-peak are permitted. This indicates that the middle and trailing Triplet Cars were hunting at 67 mph. Hunting was visible to the test crew at 60 mph and increased in severity with an increase in speed. At 67 mph, hunting was considered violent.

10.2 TWIST AND ROLL

There are three Chapter XI criteria for the Twist and Roll Test: (1) maximum roll angle of 6 degrees peak-to-peak, (2) maximum axle sum L/V of 1.3 not to exceed 50 milliseconds, and (3) minimum vertical wheel load of 10 percent of its static value not to exceed 50 milliseconds. The maximum test speed was 60 mph.

Table 10.2 is a tabulation of pre-twist and roll vertical wheel force data. This was used to determine the "static" wheel load to use in the minimum vertical wheel load percent calculations for twist and roll criteria. Instrumented Wheel set numbering is from the lead car A-end back toward the trailing Triplet Car B-end. Right is always the right side while looking from the back of the train toward the locomotives. Figure 10.1 shows the train and the instrumented wheel set numbering system.

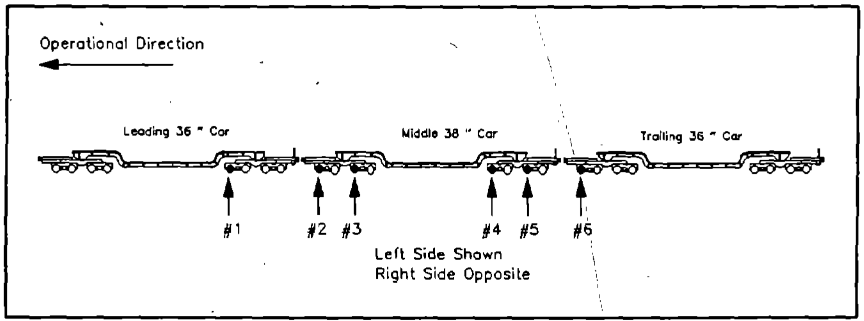

Figure 10.1 Instrumented Wheel Set Numbering System

To verify proper instrumented wheel set operation, the vehicle weights were estimated from the measured vertical wheel loads. Since only one wheel set under the leading and trailing car was instrumented, the average wheel loads were multiplied by the number of wheel sets on the car. The middle Triplet Car had four 38-inch instrumented wheel sets, which were averaged and then multiplied by eight.

Table 10.2 Triplet Rolling Unperturbed Wheel Loads (kips)

RUN NO.	8	9	10	11	12		STD DEV	EST WEIGHT
SPEED (mph)	**10**	**13**	**16**	**20**	**30**	**AVG**		
FV1R :	23.26	23.00	23.07	23.24	23.39	23.19	0.14	**LEADING**
FV1L :	25.95	26.81	26.68	26.71	26.73	26.58	0.32	398,140
FV2R :	34.13	34.10	34.19	34.18	34.10	34.14	0.04	
FV2L :	33.78	34.44	34.37	34.28	34.24	34.22	0.23	
FV3R :	39.60	38.62	38.70	--	40.12	39.26	0.63	
FV3L :	37.37	36.53	36.42	--	36.36	36.67	0.41	**MIDDLE**
FV4R :	35.31	36.04	36.46	36.66	36.66	36.23	0.51	575,650
FV4L :	36.66	36.16	35.73	35.76	36.52	36.17	0.38	
FV5R :	37.26	36.82	37.45	36.87	36.22	36.92	0.42	
FV5L :	34.16	34.50	34.85	33.97	33.60	34.22	0.43	
FV6R :	26.21	26.29	26.32	26.50	26.26	26.32	0.10	**TRAILING**
FV6L :	24.44	24.79	25.02	24.86	25.19	24.86	0.25	409,410

The light weight of the leading and trailing Triplet Cars as given by ATSF is 140,550 pounds. With the addition of 264,000 pounds from the concrete blocks, the estimated weight of each car became 404,550 pounds. This was a difference of 6,410 pounds or 1.6 percent of the total vehicle weight estimated from 1 axle of vertical wheel force data for the leading Triplet Car, and 4,860 pounds or 1.2 percent of the total estimated vehicle weight for the trailing Triplet Car. The loaded weight of the middle Triplet Car, as weighed at the TTC, was 556,900 pounds. This was a difference of 18,750 pounds or 3.2 percent of the vehicle weight as estimated from four instrumented wheel sets.

Table 10.3 through 10.5 are tabulations of the twist and roll results. All cars performed well within Chapter XI limits.

Table 10.3 Leading Triplet Car Twist and Roll Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V
10	62	0.8	.31
13	58	0.9	.36
16	57	0.9	.35
20	58	0.8	.35
27	62	1.7	.29
30	52	1.4	.41
40	58	1.7	.38
50	60	1.1	.34
56	64	1.0	.38

Table 10.4 Middle Triplet Car Twist and Roll Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V
10	67	2.2	.65
13	64	2.4	.53
16	47	3.1	.61
20	56	3.7	.58
27	58	2.2	.24
30	63	2.5	.55
40	72	1.0	.41
50	70	0.6	.40
56	70	0.6	.40

Table 10.5 Trailing Triplet Car Twist and Roll Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V
10	65	3.3	.30
13	65	1.3	.32
16	65	0.7	.34
20	63	1.0	.35
27	51	0.6	.31
30	51	1.0	.40
40	57	1.1	.36
50	60	1.0	.35
56	65	0.7	.48

10.3 PITCH AND BOUNCE

The performance criterion listed in Chapter XI for pitch and bounce was in reference to minimum vertical wheel load. The limit was 10 percent of the static wheel load not to exceed 50 milliseconds.

Table 10.6 is a tabulation for each car of the minimum vertical wheel loads in percent for the Pitch and Bounce Test. All three cars performed well within Chapter XI Criteria.

Table 10.6 Pitch and Bounce Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	WHEEL AND LOCATION
LEADING TRIPLET CAR		
30	66	1 Left
40	72	1 Left
50	68	1 Left
60	71	1 Right
MIDDLE TRIPLET CAR		
30	79	4 Right
40	80	2 Left
50	79	4 Left
60	65	4 Left
TRAILING TRIPLET CAR		
30	78	6 Right
40	77	6 Left
50	74	6 Left
60	71	6 Left

10.4 YAW AND SWAY

There are two Chapter XI criteria for the Yaw and Sway Test: (1) maximum axle sum L/V of 1.3, and (2) maximum instantaneous truck side sum L/V of 0.6. In order to obtain truck side L/V ratios, the leading truck of each span bolster on the middle Triplet Car was reconfigured with two 38-inch instrumented wheel sets. The maximum test speed was 60 mph.

Truck side L/V was not determined for the leading and trailing Triplet Cars due to an insufficient number of load measuring wheels.

Table 10.7 is a tabulation of the maximum axle sum and truck side sum L/V ratios for the yaw and sway testing runs for the middle Triplet Car. The highest axle sum L/V induced during yaw and sway testing was 1.08 at 35 mph, and the highest truck side sum was a 0.49 at 57 mph. Both values are below the Chapter XI criteria.

Table 10.7 Middle Car Yaw and Sway Results

SPEED (mph)	AXLE SUM L/V	TRUCK SIDE SUM L/V
10	0.54	0.20
15	0.71	0.28
20	0.85	0.41
25	0.97	0.35
25	0.96	0.32
30	0.97	0.42
30	1.04	0.35
35	1.08	0.40
40	1.05	0.41
45	0.99	0.38
50	1.02	0.43
55	0.82	0.47
55	0.97	0.43
57	0.96	0.49
60	0.90	0.48

10.5 TURNOUT AND CROSSOVER

There are no official limiting Chapter XI criteria for the turnout and crossover tests because these tests are not official Chapter XI tests. The wheel L/V criteria of 0.8 and axle sum criteria of 1.3 neither to exceed 50 milliseconds were used as guidelines.

Table 10.8 summarizes wheel L/V and axle sum L/V for the turnout and crossover results for each car. The turnout axle sum L/V for the trailing Triplet Car exceeded guideline with a 1.32 L/V, however, the duration above 1.3 was only 20 milliseconds.

Crossover L/V values were considerably below the 0.8 and 1.3 wheel and axle sum L/V criteria, respectively.

Table 10.8 Turnout and Crossover Results

TEST	SPEED (mph)	MAXIMUM WHEEL L/V	MAXIMUM AXLE SUM L/V	mSEC OVER 1.3
LEADING TRIPLET CAR				
Turnout	10	0.77	1.27	--
Turnout	15	0.74	1.23	--
Crossover	10	0.63	1.01	--
Crossover	20	0.67	1.12	--
MIDDLE TRIPLET CAR				
Turnout	10	0.69	1.15	--
Turnout	15	0.63	1.14	--
Crossover	10	0.55	0.98	--
Crossover	20	0.56	1.01	--
TRAILING TRIPLET CAR				
Turnout	10	0.79	1.32	20
Turnout	15	0.55	1.28	--
Crossover	10	0.54	0.93	--
Crossover	20	0.55	1.08	--

10.6 DYNAMIC CURVING

Chapter XI specifies limiting values for the following four parameters: (1) maximum wheel L/V of 0.8 not to exceed 50 milliseconds, (2) maximum axle sum L/V of 1.3 not to exceed 50 milliseconds, (3) maximum roll angle of 6 degrees peak-to-peak, and (4) a minimum vertical wheel load of 10 percent not to last more than 50 milliseconds.

The test was performed in both the clockwise and counterclockwise directions. To help ensure safety, two additional IITRI instrumented wheel sets were installed. One was installed in the leading axle of the leading span bolster (# 7), and the other in the leading axle of the trailing span bolster (# 8), as shown in Figure 10.3.

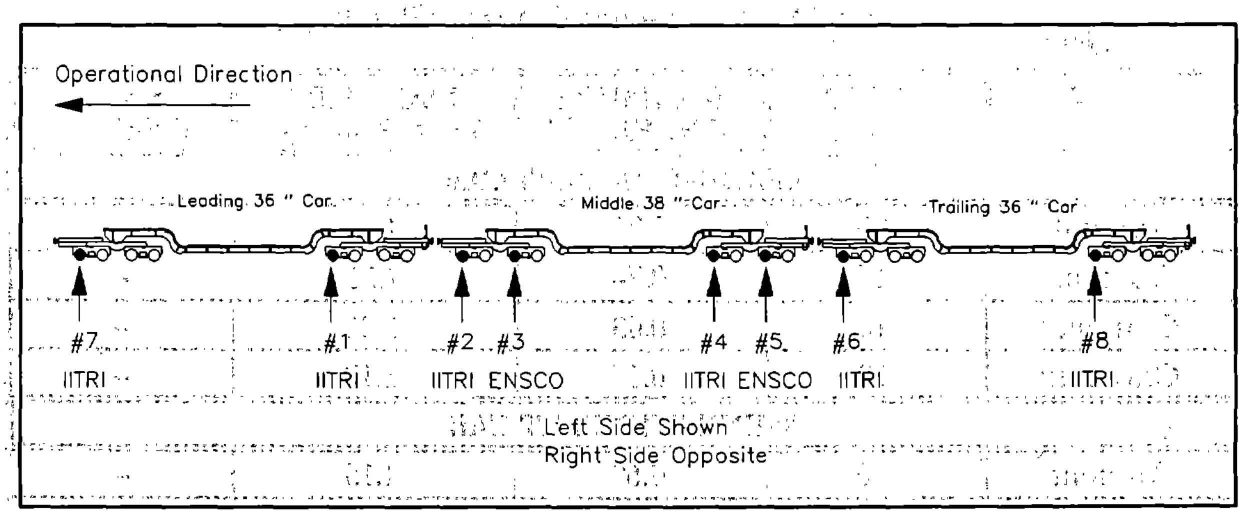

Figure 10.3 Dynamic Curving Instrumented Wheel set Placement

Table 10.9 summarizes the leading Triplet Car dynamic curving testing results in the clockwise directions. The majority of the wheel unloading on the car came from wheel 1 on the right side (1R). The minimum wheel load was 29 percent. The maximum wheel L/V ratios were all from wheel 7 on the left side (7L). Maximum axle sums for the car occurred on axle 7. The car's maximum wheel and axle sum L/V occurred at 24 mph. All measured values were within Chapter XI criteria.

Table 10.9 Leading Triplet Car Dynamic Curving Results Clockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	AXLE SUM L/V	mSEC OVER 1.3	WHEEL L/V
12	48	1.17	--	.69
14	51	1.26	--	.74
16	57	1.27	--	.73
18	55	1.26	--	.73
20	63	1.26	--	.76
22	53	1.26	--	.77
24	49	1.32	20	.79
26	44	1.30	--	.78
28	46	1.28	--	.78
30	43	1.24	--	.76
32	29	1.23	--	.74

Note: Roll angle was not recorded due to equipment malfunction.

Table 10.10 summarizes the middle Triplet Car's dynamic curving test results in the clockwise directions. Wheel 3L produced the highest percent of unloading for the middle Triplet Car during lower speed testing. Maximum unloading at higher speeds fluctuated from wheel to wheel, but the highest unloading always occurred on the right side. Wheel L/V ratios for the car followed a definite pattern. Wheel 2L had the highest L/V ratios from 12-22 mph, and wheel 3L had the highest L/V ratios from 24-32 mph. The peak wheel L/V was 1.02 and the peak axle sum L/V was 1.52, both occurring at 26 mph. Both of these values exceeded Chapter XI criteria. Chapter XI criteria were exceeded for more than 50 milliseconds at 18, 20, 22, 24, 26, and 28 mph. Roll angles on the car ranged from 1.1 to 2.7 degrees peak-to-peak. The B-end of the car recorded slightly higher roll angles than the A-end.

Table 10.10 Middle Triplet Car Dynamic Curving Results Clockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V	mSEC OVER 1.3	WHEEL L/V	mSEC OVER 0.8
12	56	1.1	1.19	--	.70	--
14	53	1.3	1.21	--	.72	--
16	54	1.6	1.33	40	.82	30
18	49	2.1	1.38	85	.89	90
20	44	2.5	1.36	100	.85	85
22	43	2.5	1.42	115	.95	110
24	43	2.7	1.41	95	.90	60
26	50	2.6	1.52	80	1.02	100
28	56	2.5	1.42	75	.91	80
30	55	2.2	1.29	--	.79	--
32	46	2.1	1.17	--	.67	--

Figure 10.4 is a time history plot of the middle Triplet Car wheel L/V ratio during the 22 mph clockwise run.

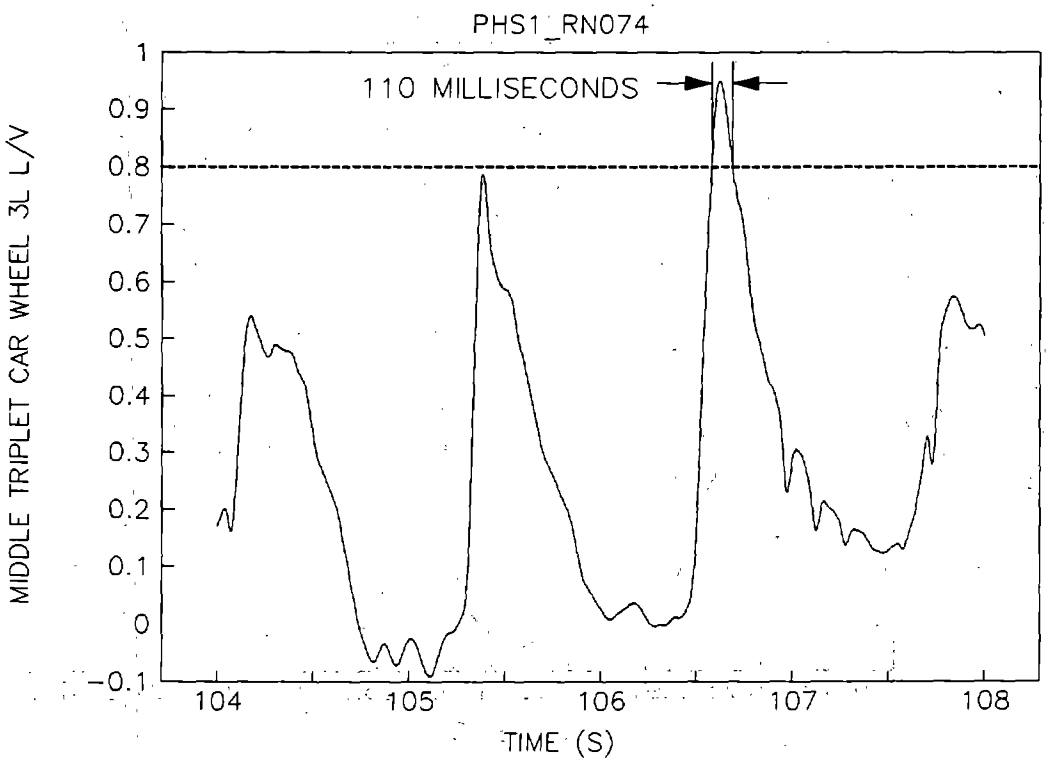

Figure 10.4 Time History Plot of the Middle Triplet Car Wheel 3L L/V

This four second time frame shows the middle Triplet Car wheel 3L exceeding the 0.8 wheel L/V Chapter XI limit, which is represented in this plot by the horizontal dashed line. Wheel 3L yielded a maximum L/V of .95 and exceeded Chapter XI criteria for 110 milliseconds.

Figure 10.5 is a time history plot of the middle Triplet Car axle 3 sum L/V during the 22 mph clockwise run.

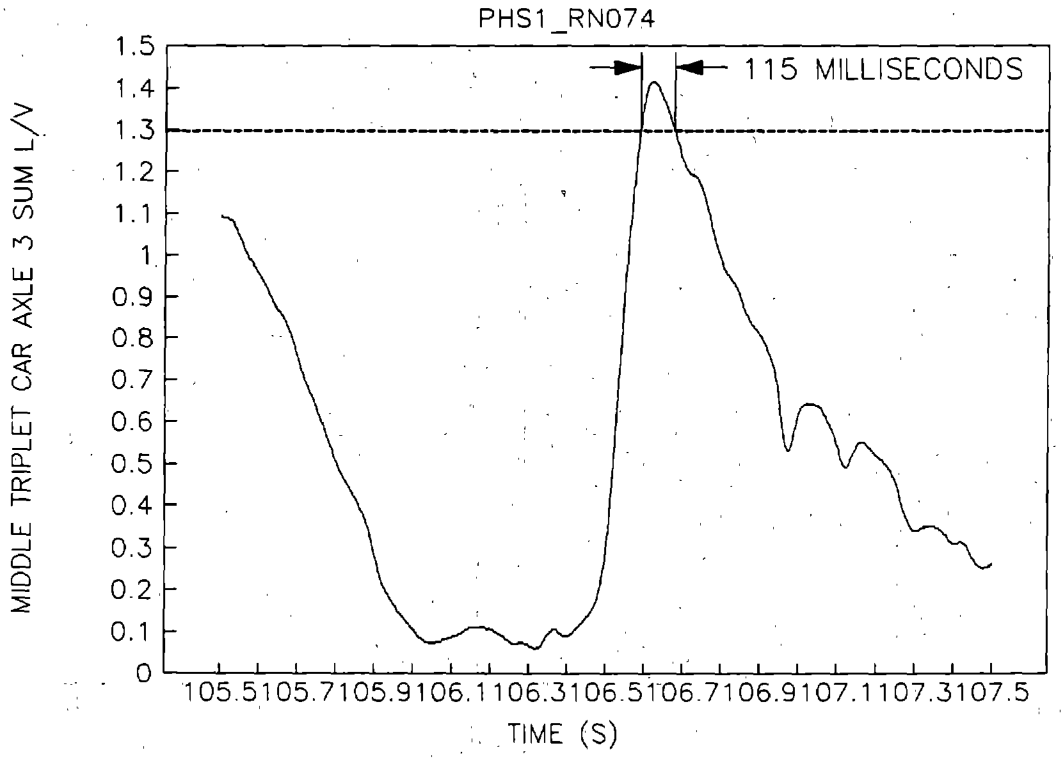

Figure 10.5 Time History Plot of the Middle Triplet Car Axle 3 Sum L/V

This two second time frame during dynamic curving shows the middle Triplet Car axle 3 exceeding the 1.3 axle sum L/V Chapter XI limit, which is represented in this plot by the horizontal dashed line. Axle 3 yielded a maximum L/V of 1.42 and exceeded Chapter XI criteria for 115 milliseconds.

Table 10.11 summarizes the trailing Triplet Car dynamic curving testing results in the clockwise directions. Maximum wheel unloading for the car followed an expected trend. Wheel unloading at speeds of 12-22 mph were all left side, high rail wheels (6L and 8L), but from 24-32 mph unloading shifted to right side, low rail wheels (6R and 8R). Wheel 8L always yielded the highest wheel L/V with the exception of 32 mph where 6L yielded a slightly higher value. The maximum wheel L/V was 0.84 at 24 mph, but the duration above 0.8 was only 30 milliseconds. Axle 8 always yielded the highest axle sum L/V values. The maximum axle sum L/V of 1.4 which lasted for 40 milliseconds was recorded at 24 mph. Chapter XI criteria were not exceeded for clockwise operation in the dynamic curve test.

Table 10.11 Trailing Triplet Car Dynamic Curving Results Clockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	AXLE SUM L/V	mSEC OVER 1.3	WHEEL L/V	mSEC OVER 0.8
12	60.18	1.23	--	.72	--
14	70.92	1.28	--	.78	--
16	64.74	1.33	15	.76	--
18	57.92	1.38	35	.78	--
20	70.27	1.32	25	.79	--
22	60.58	1.36	35	.83	25
24	53.34	1.40	40	.84	30
26	51.18	1.34	25	.80	--
28	51.79	1.31	10	.78	--
30	43.05	1.30	--	.80	--
32	32.29	1.27	--	.78	--

Note: Roll angle was not recorded due to equipment malfunction.

Table 10.12 summarizes the leading Triplet Car dynamic curving testing results in the counterclockwise direction. Wheel 1R produced the highest percent of wheel unloading from 8-16 mph, and wheel 1L produced the highest percent of wheel unloading from 18-30 mph. The highest percent of wheel unloading recorded for the car was 40 percent at 30 mph.

Wheel 7R yielded the highest wheel L/V ratios from 8-14 mph, and wheel 1R yielded the highest values from 16-30 mph. The maximum wheel L/V occurred at 28 mph and was 0.86 sustained for 35 milliseconds. Axles 1 and 7 produced the highest axle sum L/V ratios. The maximum axle sum L/V was 1.37 and occurred at 8 and 16 mph. The Leading Triplet Car exceeded Chapter XI with an axle sum L/V of 1.37 for 70 milliseconds over 1.3.

Table 10.12 Leading Triplet Car Dynamic Curving Results Counterclockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	AXLE SUM L/V	mSEC OVER 1.3	WHEEL L/V	mSEC OVER 0.8
8	63	1.37	70	.78	--
12	66	1.27	--	.74	--
14	62	1.31	5	.74	--
16	63	1.37	40	.80	--
18	63	1.32	15	.81	10
20	55	1.30	--	.81	10
22	51	1.27	--	.78	--
24	52	1.32	25	.79	--
26	45	1.24	--	.79	--
28	46	1.34	20	.86	35
30	40	1.31	10	.84	30

Note: Roll angle was not recorded due to equipment malfunction.

Table 10.13 summarizes the middle Triplet Car dynamic curving testing results in the counterclockwise direction. Wheel 4R produced the highest percent of wheel unloading from 8-18 mph. The highest percent of wheel unloading recorded for the car was 41.9 percent at 30 mph.

Wheels 2, 3, 4, and 5 right all recorded a high L/V between 8-16 mph. Between 18 and 30 mph, wheel 4R consistently produced the highest L/V ratio. The maximum wheel L/V occurred at 8 mph and was 0.72. The extreme underbalance condition at such a low speed is the probable cause. Axle sum L/V ratios followed the same pattern as wheel L/V ratios. The maximum axle sum L/V was 1.28 and occurred at 8 mph. Roll angles produced during dynamic curving ranged between 1.5 and 3.1 degrees. Chapter XI criteria were not exceeded.

Table 10.13 Middle Triplet Car Dynamic Curving Results Counterclockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD (%)	ROLL ANGLE (deg)	AXLE SUM L/V	WHEEL L/V
8	58	1.5	1.28	.72
12	61	2.5	1.18	.69
14	64	2.0	1.18	.69
16	59	1.6	1.15	.70
18	60	2.3	1.24	.70
20	60	3.1	1.20	.70
22	54	2.8	1.22	.69
24	51	2.6	1.21	.71
26	53	2.5	1.19	.68
38	52	2.3	1.19	.66
30	42	1.6	1.15	.67

Table 10.14 summarizes the trailing Triplet Car dynamic curving testing results in the counterclockwise direction. Maximum wheel unloading for the car was not limited to a specific axle nor to a specific side. The maximum percent of wheel unloading was 44 percent at 30 mph.

Wheel 8R had wheel L/V ratios above the Chapter XI criteria of 0.8, however, the duration was less than the 50 millisecond criteria. The maximum wheel L/V occurred at 14 mph and was 0.83. Axles sum L/V ratios followed the same pattern as wheel L/V ratios with the exception of axle 6 at 8 and 22 mph. The maximum axle sum L/V was 1.52 at 28 mph for a duration of 40 milliseconds, thus not exceeding Chapter XI.

Table 10.14 Trailing Triplet Car Dynamic Curving Results
Counterclockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	AXLE SUM L/V	mSEC OVER 1.3	WHEEL L/V	mSEC OVER 0.8
8	61	1.31	5	.74	--
12	68	1.25	--	.70	--
14	66	1.42	40	.83	15
16	67	1.38	10	.78	--
18	59	1.31	15	.76	--
20	55	1.34	15	.70	--
22	67	1.29	--	.72	--
24	54	1.33	20	.79	--
26	51	1.36	45	.78	--
28	46	1.52	40	.82	10
30	44	1.32	10	.75	--

Note: Roll angle was not recorded due to equipment malfunction.

10.7 CONSTANT CURVING

Constant curving tests were performed on the 7.5- and 12-degree curves of the WRM. Curve entry, steady state curving, and curve exit were analyzed independently. The two Chapter XI criteria for steady state curving are 95th percentile wheel and axle L/V of 0.8 and 1.3, respectively. The two criteria for curve entry and exit are maximum wheel L/V of 0.8 and minimum percent vertical wheel load of 10 percent sustained for 50 milliseconds. Table 10.15 is a tabulation of the 7.5-degree curve entry test results and predictions.

Table 10.15 7.5-Degree Curve Entry Results -- CW and CCW Direction

SPEED (mph)	DIR	WHEEL L/V	PRED WHEEL L/V	MINIMUM WHEEL LOAD %	PRED WHEEL LOAD	AXLE SUM L/V
LEADING TRIPLET CAR						
14 (10)	CW	.56	.50	58	60	1.07
24	CW	.54	.47	65	62	1.04
32 (34)	CW	.52	.51	68	46	.96
16	CCW	.64	--	74	--	1.11
24	CCW	.65	--	74	--	1.13
32	CCW	.57	--	73	--	1.01
MIDDLE TRIPLET CAR						
14 (10)	CW	.58	.53	69	63	1.09
24	CW	.54	.54	68	62	.97
32 (34)	CW	.49	.39	63	55	.94
16	CCW	.55	--	69	--	.99
24	CCW	.49	--	68	--	.95
32	CCW	.49	--	62	--	.92
TRAILING TRIPLET CAR						
14 (10)	CW	.66	.48	68	60	1.14
24	CW	.55	.47	63	62	.96
32 (34)	CW	.53	.51	47	46	.89
16	CCW	.52	--	70	--	.96
24	CCW	.61	--	67	--	1.07
32	CCW	.53	--	66	--	1.00

( ) Model Speed

The directional change from clockwise to counterclockwise produced no significant increase or decrease in values. All cars performed well within Chapter XI criteria. Figure 10.6 shows a comparison of wheel L/V versus the TDM predicted wheel L/V and a comparison of minimum vertical wheel load versus predicted minimum vertical wheel load in percent for the 7.5-degree curve entry.

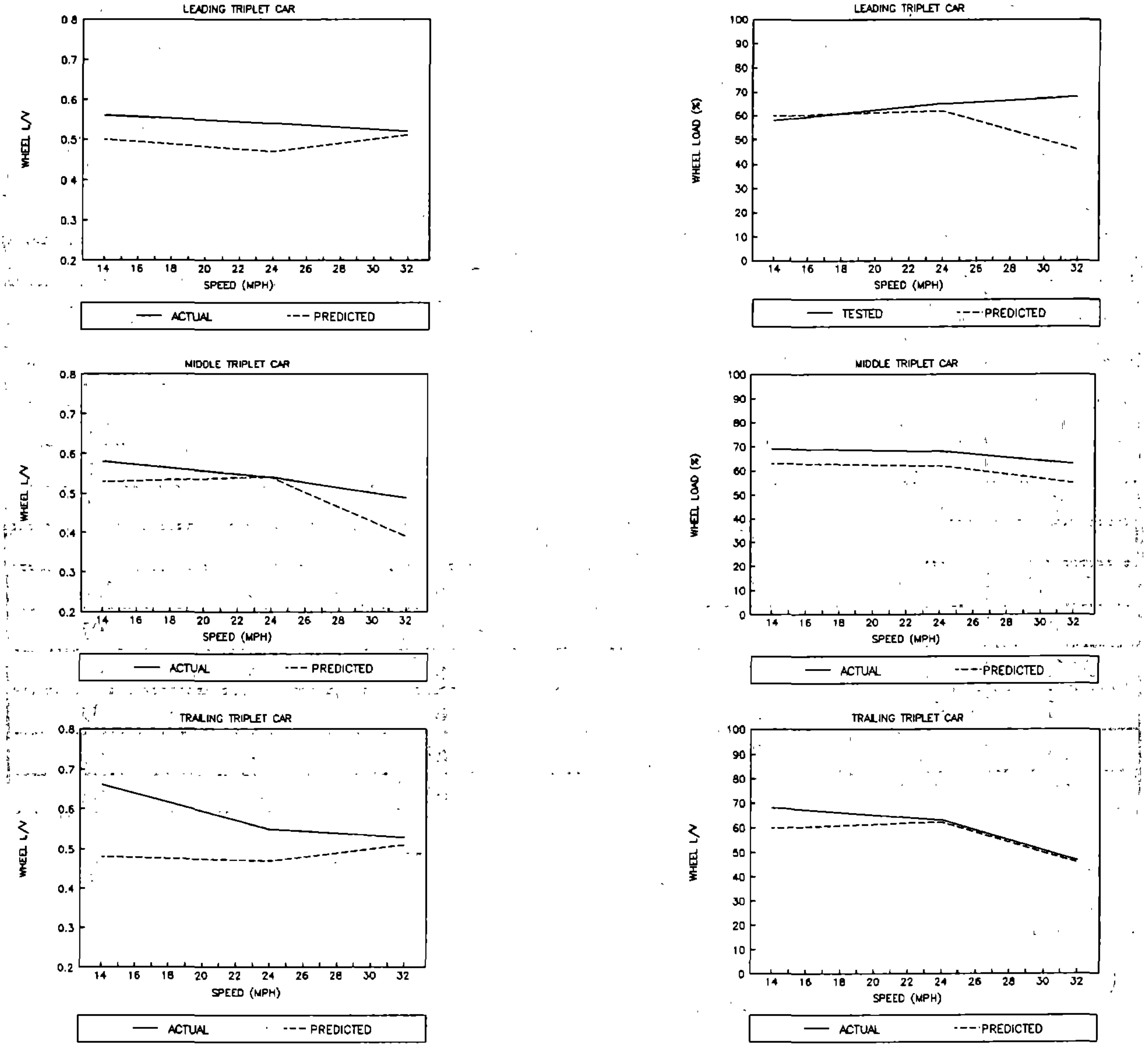

Figure 10.6 7.5-Degree Curve Entry Results Versus Predicted Wheel L/V and Minimum Percent Wheel Load

All cars had values well within Chapter XI criteria for the 7.5-degree steady state curving test (Table 10.16). The leading Triplet Car produced higher wheel and axle sum L/V's in the counterclockwise direction. In the counterclockwise direction, the consist exited the 12-degree curve then immediately entered the 7.5-degree curve (a reverse curve).

Table 10.16 7.5-Degree Steady State Results -- CW and CCW Direction

SPEED (mph)	DIR	WHEEL L/V	95 % WHEEL L/V	PRED WHEEL L/V	AXLE SUM L/V	95 % AXLE SUM L/V	PRED AXLE SUM L/V
LEADING TRIPLET CAR							
14 (10)	CW	.44	.35	.48	.78	.67	.93
24	CW	.47	.35	.40	.88	.67	.80
32 (34)	CW	.43	.35	.36	.81	.69	.73
14	CCW	.66	.53	--	1.12	.95	--
24	CCW	.65	.54	--	1.08	.96	--
32	CCW	.62	.51	--	1.05	.90	--
MIDDLE TRIPLET CAR							
14 (10)	CW	.58	.45	.47	1.02	.84	.90
24	CW	.53	.44	.40	.99	.83	.81
32 (34)	CW	.55	.42	.37	1.00	.83	.70
14	CCW	.61	.51	--	1.06	.93	--
24	CCW	.55	.46	--	1.01	.87	--
32	CCW	.51	.39	--	.91	.77	--
TRAILING TRIPLET CAR							
14 (10)	CW	.58	.46	.46	1.03	.84	.91
24	CW	.60	.47	.40	1.04	.83	.80
32 (34)	CW	.61	.43	.36	1.04	.80	.72
14	CCW	.59	.47	--	1.02	.87	--
24	CCW	.62	.49	--	1.07	.91	--
32	CCW	.61	.48	--	1.08	.90	--

( ) Model Speed

Figure 10.7 shows a comparison of maximum and 95 percentile wheel L/V versus the TDM predicted wheel L/V and a comparison of maximum and 95 percentile axle sum L/V versus predicted axle sum L/V for the 7.5-degree steady state curving.

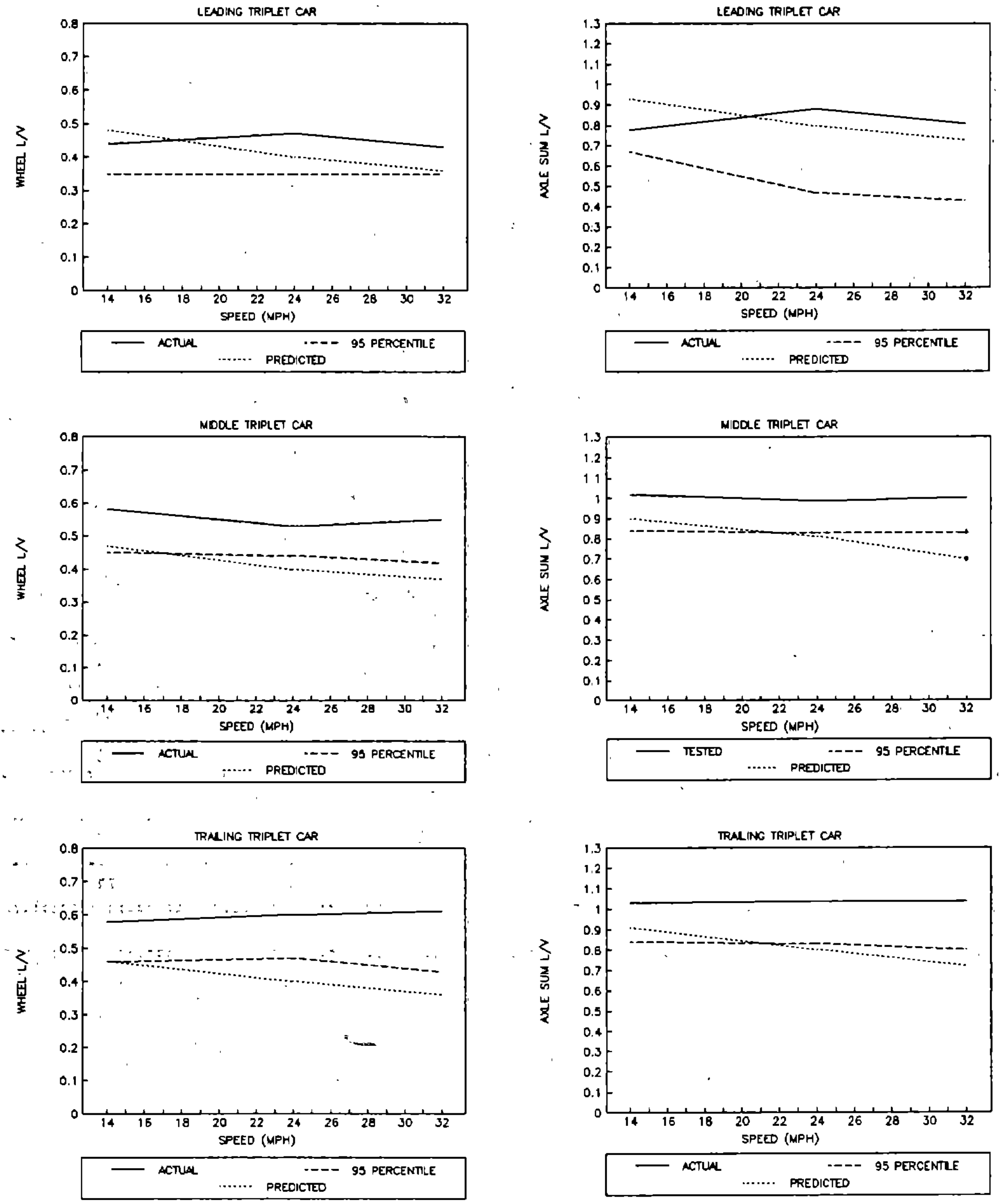

Figure 10.7 7.5-Degree Curve Steady State Results Versus Predicted Wheel L/V and Minimum Percent Wheel Load

Table 10.17 is a tabulation of the 7.5-degree curve exit test results and predictions. All cars had wheel L/V ratios below 0.65. Axle sum L/V ratios for all cars were below 1.15. Both measurements were unaffected by direction of operation. All cars had values within Chapter XI criteria.

Table 10.17 7.5-Degree Curve Exit Results -- **CW and CCW Direction**

SPEED (mph)	DIR	WHEEL L/V	PRED WHEEL L/V	MINIMUM WHEEL LOAD %	PRED WHEEL LOAD %	AXLE SUM L/V
LEADING TRIPLET CAR						
14 (10)	CW	.51	.48	74	60	.89
24	CW	.47	.45	73	62	.83
32 (34)	CW	.49	.38	64	54	.91
16	CCW	.47	--	75	--	.85
24	CCW	.47	--	66	--	.85
32	CCW	.45	--	61	--	.80
MIDDLE TRIPLET CAR						
14 (10)	CW	.50	.47	67	63	.95
24	CW	.57	.42	75	62	1.00
32(34)	CW	.48	.37	62	56	.90
16	CCW	.49	--	74	--	.88
24	CCW	.48	--	68	--	.92
32	CCW	.40	--	54	--	.73
TRAILING TRIPLET CAR						
14 (10)	CW	.53	.50	67	56	.96
24	CW	.48	.45	73	60	.90
32 (34)	CW	.49	.38	71	53	.81
16	CCW	.57	--	77	--	1.02
24	CCW	.65	--	47	--	1.14
32	CCW	.54	--	52	--	.97

( ) Model Speed

Figure 10.8 shows a comparison of wheel L/V versus the TDM predicted wheel L/V and a comparison of minimum vertical wheel load versus predicted minimum vertical wheel load in percent for the 7.5-degree curve exit.

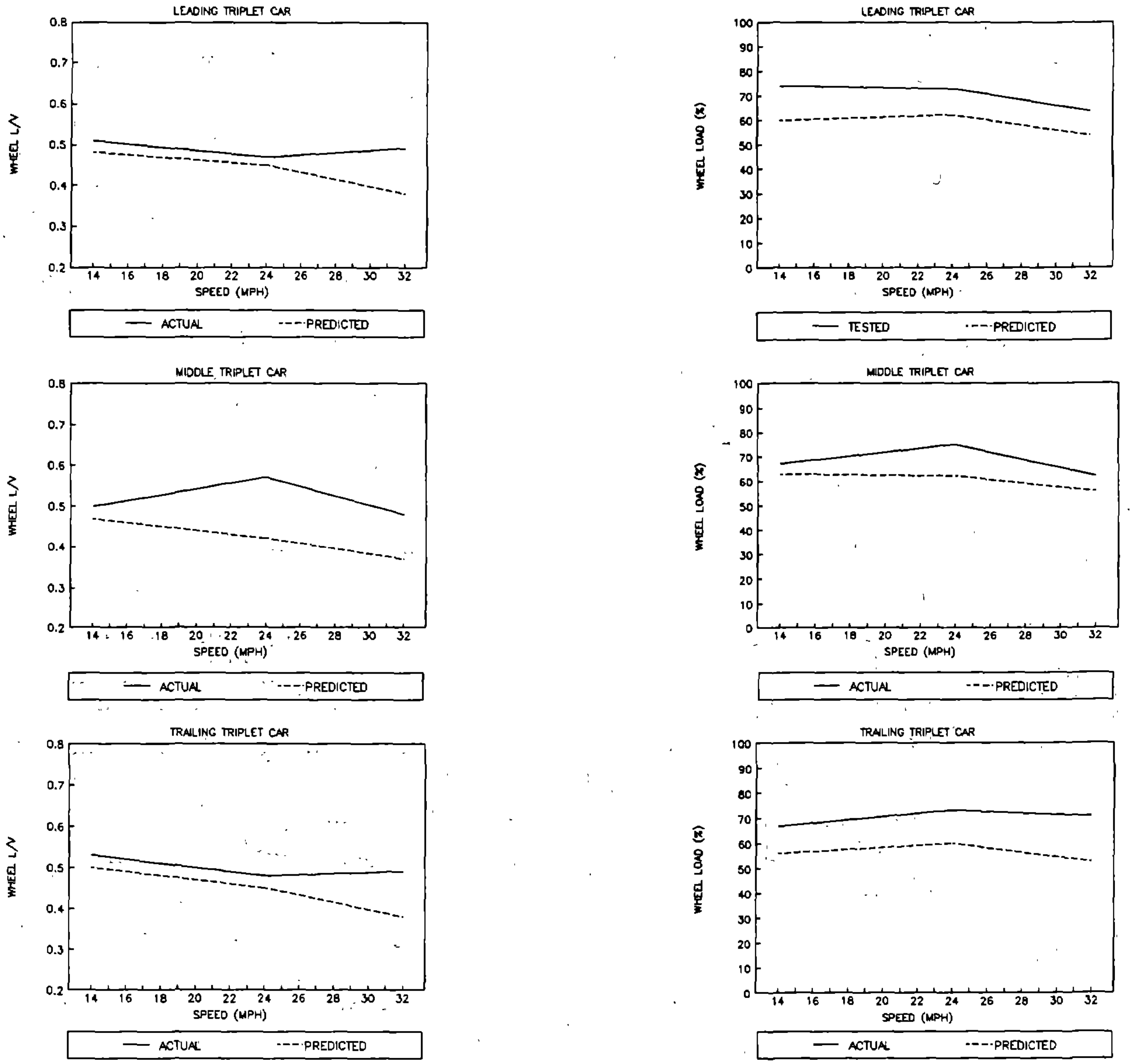

Figure 10.8 7.5-Degree Curve Exit Results Versus Predicted Wheel L/V and Minimum Percent Wheel Load

Table 10.18 is a tabulation of the 12-degree curve entry test results and predictions. The leading Triplet Car exceeded Chapter XI wheel L/V criteria at 28 mph with an L/V of 0.88 sustained for 75 milliseconds over 0.8. The middle and trailing Triplet Cars did not exceed Chapter XI criteria in the clockwise or counterclockwise directions. A direct comparison between the leading and trailing car cannot be made due to different instrumented wheel set placement.

Table 10.18 12-Degree Curve Entry Results -- CW and CCW Direction

SPEED (mph)	DIR	WHEEL L/V		PRED MAXIMUM WHEEL L/V	MINIMUM WHEEL LOAD (%)	PRED WHEEL Load (%)	AXLE SUM L/V	
		PEAK	mSEC OVER 0.8				PEAK	mSEC OVER 1.3
LEADING TRIPLET CAR								
16 (15.5)	CW	.81	25	.74	69	38	1.31	10
24 (24.5)	CW	.84	30	.72	61	34	1.32	15
28 (31)	CW	.88	75	.72	68	21	1.37	35
16	CCW	.68	--	--	71	--	1.17	--
24	CCW	.66	--	--	72	--	1.15	--
MIDDLE TRIPLET CAR								
16 (15.5)	CW	.78	--	.72	61	43	1.19	--
24 (24.5)	CW	.73	--	.76	67	36	1.19	--
28 (31)	CW	.69	--	.60	59	30	1.17	--
16	CCW	.81	30	--	56	--	1.29	--
24	CCW	.61	--	--	57	--	1.11	--
TRAILING TRIPLET CAR								
16 (15.5)	CW	.67	--	.74	65	38	1.18	--
24 (24.5)	CW	.66	--	.73	64	35	1.18	--
28 (31)	CW	.65	--	.72	64	21	1.16	--
16	CCW	.69	--	--	39	--	1.20	--
24	CCW	.67	--	--	29	--	1.16	--

( ) Model Speed

Figure 10.9 shows a comparison of wheel L/V versus the TDM predicted wheel L/V and a comparison of minimum vertical wheel load versus predicted minimum vertical wheel load in percent for the 12-degree curve entry.

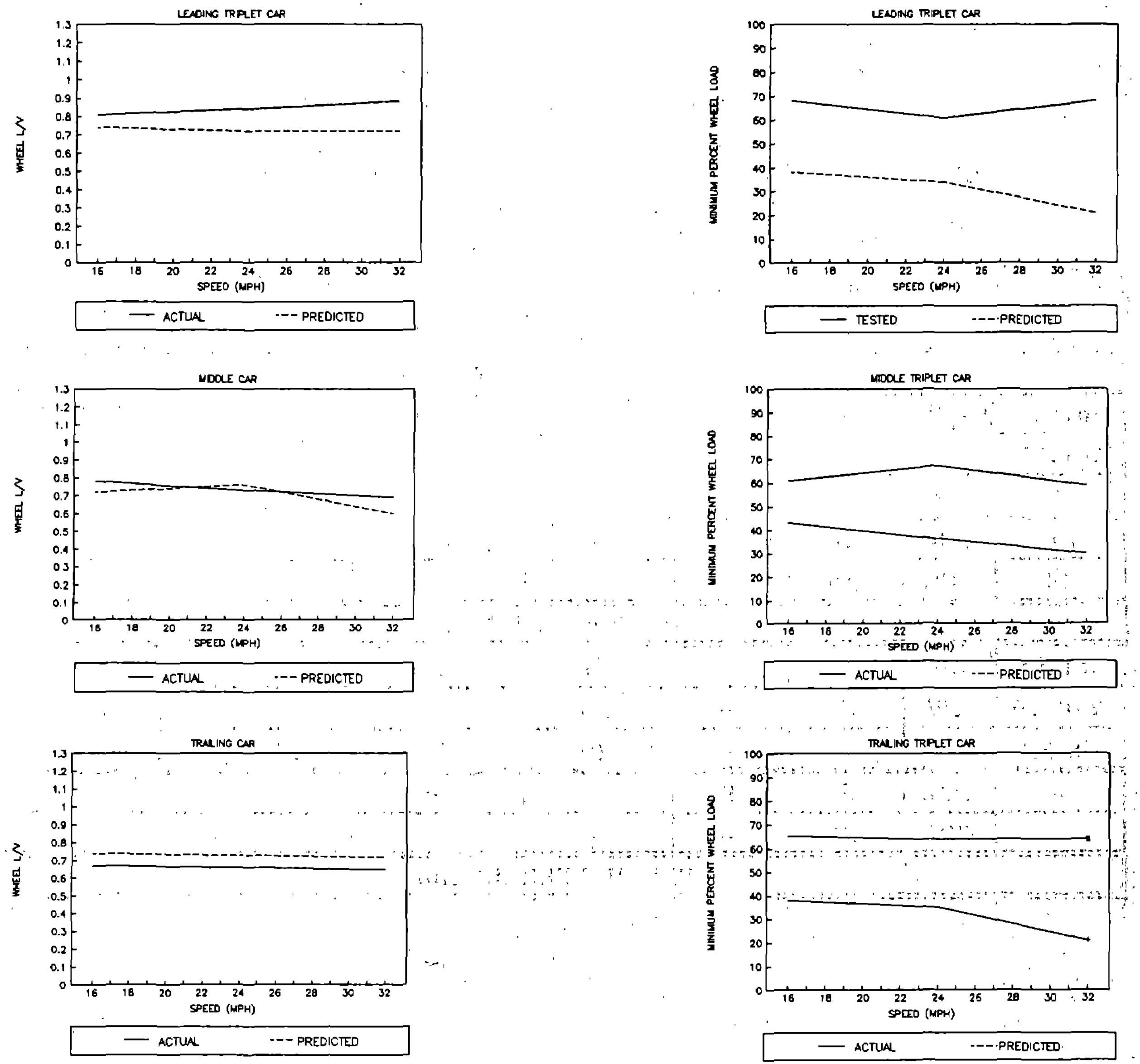

Figure 10.9 12-Degree Curve Entry Results Versus Predicted Wheel L/V and Minimum Percent Wheel Load

Table 10.19 is a tabulation of the 12-degree steady state curving test results and predictions. All cars performed within Chapter XI criterion during 12-degree steady state curving. The maximum speed in the counterclockwise direction was limited to 24 mph due to speed restrictions through the adjacent dynamic curving section of the track.

Table 10.19 12-Degree Steady State Results -- CW and CCW Direction

SPEED (mph) (mph)	**DIR**	**WHEEL L/V**			**PRED MAX WHEEL L/V**	**AXLE SUM L/V**			**PRED MAX AXLE L/V**
		PEAK	**DUR OVER 0.8**	**95 %**		**PEAK**	**DUR OVER 1.3**	**95 %**	
LEADING TRIPLET CAR									
16 (15.5)	CW	.77	--	.68	--	1.30	--	1.17	--
24 (24.5)	CW	.79	--	.68	.48	1.26	--	1.15	.96
28 (31)	CW	.77	--	.63	.47	1.25	--	1.11	.92
16	CCW	.72	--	.57	--	1.25	--	1.05	--
24	CCW	.74	--	.55	--	1.22	--	1.03	--
MIDDLE TRIPLET CAR									
16 (15.5)	CW	.65	--	.61	--	1.16	--	1.11	--
24 (24.5)	CW	.66	--	.63	.47	1.18	--	1.12	.95
28 (31)	CW	.66	--	.61	.48	1.19	--	1.11	.88
16	CCW	.80	--	.68	--	1.30	--	1.20	--
24	CCW	.67	--	.58	--	1.21	--	1.10	--
TRAILING TRIPLET CAR									
16 (15.5)	CW	.63	--	.55	--	1.15	--	1.04	--
24 (24.5)	CW	.62	--	.54	.48	1.13	--	1.03	.96
28 (31)	CW	.62	--	.55	.47	1.13	--	1.04	.92
16	CCW	.81	25	.65	--	1.35	35	1.15	--
24	CCW	.78	--	.61	--	1.31	10	1.10	--

( ) Model Speed

Figure 10.10 shows a comparison of wheel L/V versus the TDM predicted wheel L/V and a comparison of axle sum L/V versus predicted axle sum L/V for the 12-degree steady state curving. No wheel L/V or axle sum L/V predictions were made for the 16 mph 12-degree steady state curving runs.

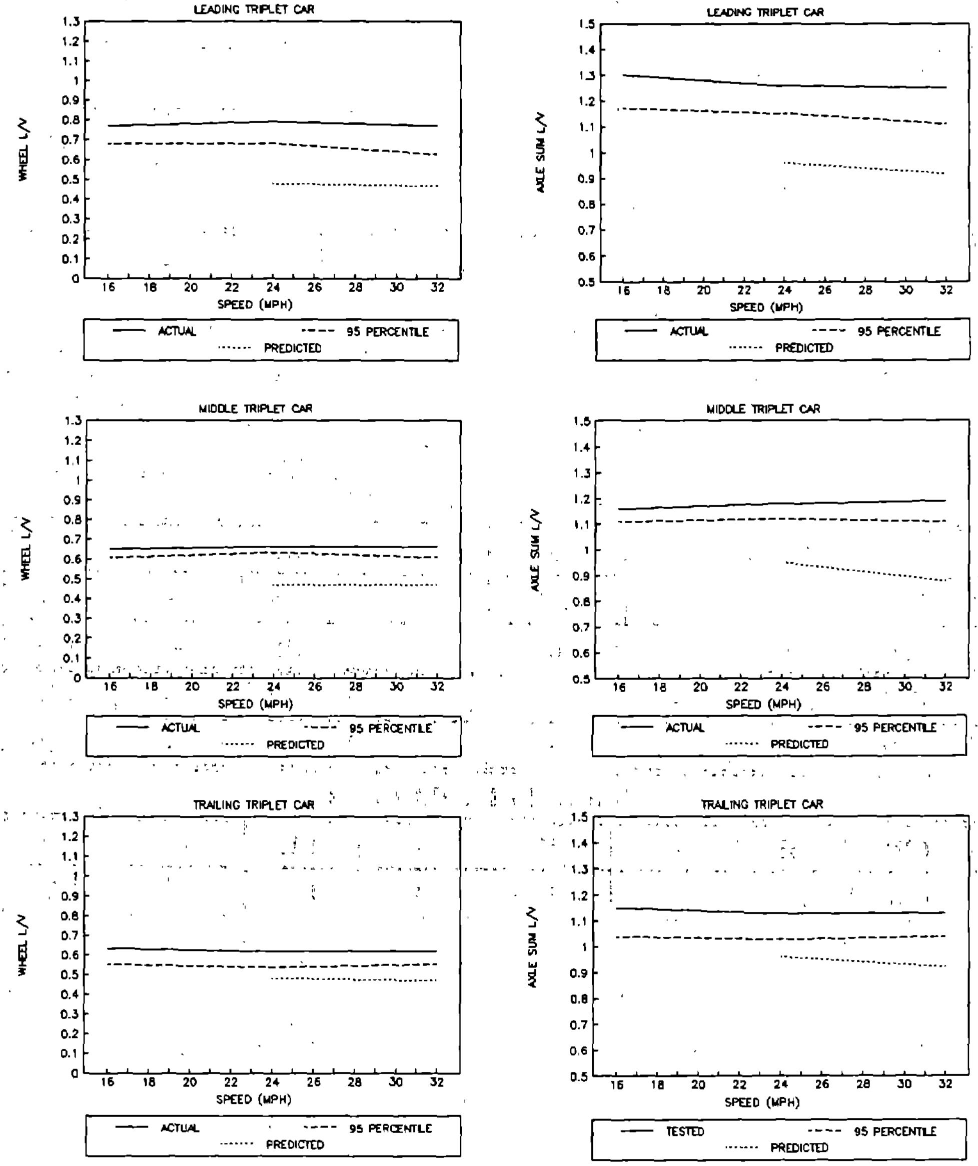

Figure 10.10 12-Degree Curve Steady State Results Versus Predicted Wheel L/V and Axle Sum L/V

Table 10.20 is a tabulation of the 12-degree curve exit test results and predictions. The leading and middle Triplet Cars negotiated the curve exit within Chapter XI criterion in both the clockwise and counterclockwise directions. The trailing Triplet Car, however, exceeded Chapter XI criteria at underbalance, balance, and overbalance speeds when exiting through the bunched spiral. Exiting the 12-degree curve in the clockwise direction is over the bunched spiral, exiting the counterclockwise direction is over a normal spiral. The trailing Triplet Car exceeded Chapter XI criteria.

Table 10.20 12-Degree Curve Exit Results -- CW and CCW Direction

SPEED (mph)	DIR	WHEEL L/V		PRED WHEEL L/V	MAXIMUM WHEEL LOAD %	PRED AXLE L/V	AXLE SUM L/V	
		PEAK	mSEC OVER 0.8				PEAK	mSEC OVER 1.3
LEADING TRIPLET CAR								
16 (15.5)	CW	.69	--	--	73.8	--	1.20	--
24 (24.5)	CW	.74	--	1.08	69.2	36	1.24	--
28 (31)	CW	.74	--	1.00	72.5	28	1.23	--
16	CCW	.73	--	--	70.3	--	1.20	--
24	CCW	.74	--	--	68.7	--	1.22	--
MIDDLE TRIPLET CAR								
16 (15.5)	CW	.75	--	--	54.9	--	1.16	--
24 (24.5)	CW	.76	--	.85	53.4	36	1.19	--
28 (31)	CW	.77	--	.61	55.5	41	1.19	--
16	CCW	.83	30	--	52.5	--	1.30	--
24	CCW	.75	--	--	61.3	--	1.23	--
TRAILING TRIPLET CAR								
16 (15.5)	CW	.93	300	--	40.7	--	1.28	--
24 (24.5)	CW	1.10	400	1.07	39.9	35	1.48	230
28 (31)	CW	1.12	350	.98	41.8	27	1.50	225
16	CCW	.81	25	--	58.3	--	1.30	--
24	CCW	.78	--	--	69.0	--	1.27	--

( ) Model Speed

Chapter XI states that no wheel L/V shall exceed 0.8 for greater than 50 milliseconds. The trailing Triplet Car exceeded three times with durations of 300, 350 and 400 milliseconds. This car also exceeded the axle sum criteria of 1.3 for a duration of 230 and 225milliseconds. All cars performed within Chapter XI criteria in the counterclockwise direction exiting the normal spiral. Figure 10.11 is a time history plot showing the wheel L/V ratio of the trailing Triplet Car during the 24 mph test run (PHS1_RN025) in the clockwise direction.

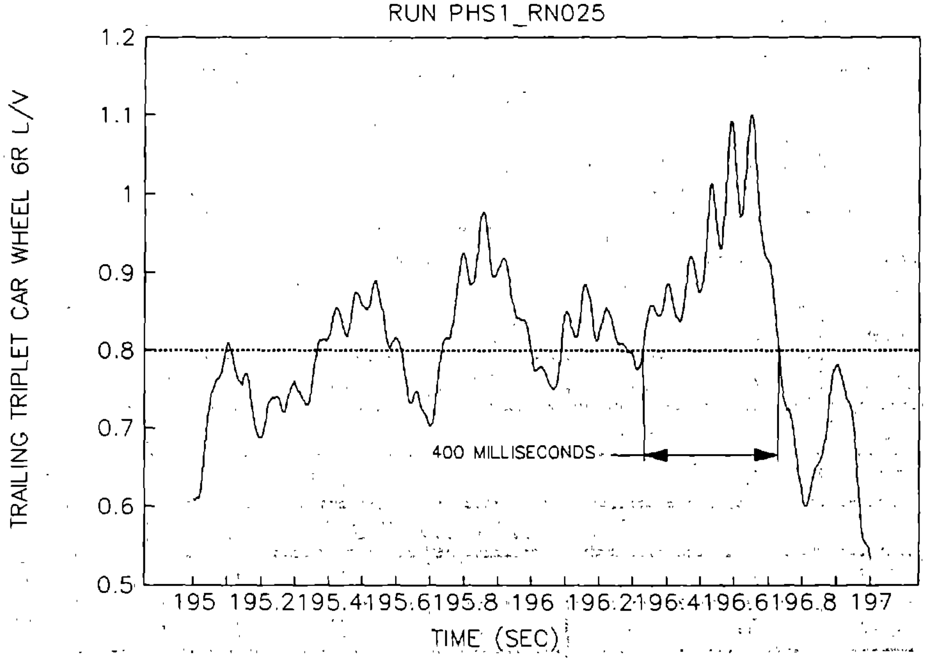

Figure 10.11 Wheel L/V Time History of 24 mph Run

The two second time frame shows the trailing Triplet Car wheel 6R exceeding the 0.8 wheel L/V Chapter XI limit multiple times while exiting the bunched spiral. Wheel 6R yielded an L/V of 1.10 and exceeded Chapter XI criteria for 400 milliseconds.

Figure 10.12 is a time history plot showing the axle sum L/V of the trailing Triplet Car during the 24 mph test run (PHS1_RN025) in the clockwise direction.

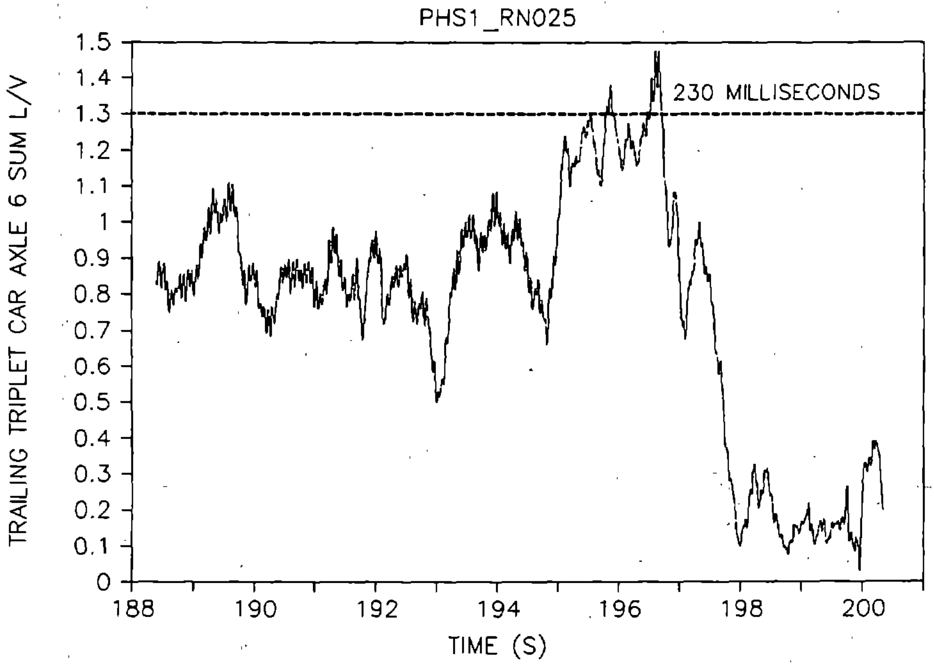

Figure 10.12 Axle sum L/V Time History for 24 mph Run

This time frame shows the trailing Triplet Car exceeding the 1.3 axle sum L/V Chapter XI limit during two separate occurrences. The largest axle sum being 1.48 and lasting 230 milliseconds.

Figure 10.13 shows a comparison of wheel L/V versus the TDM predicted wheel L/V and a comparison of minimum vertical wheel load versus predicted minimum vertical wheel load in percent for the 12-degree curve exit. Wheel L/V and minimum percent wheel load predictions were not made for the 16 mph 12-degree curve exit runs.

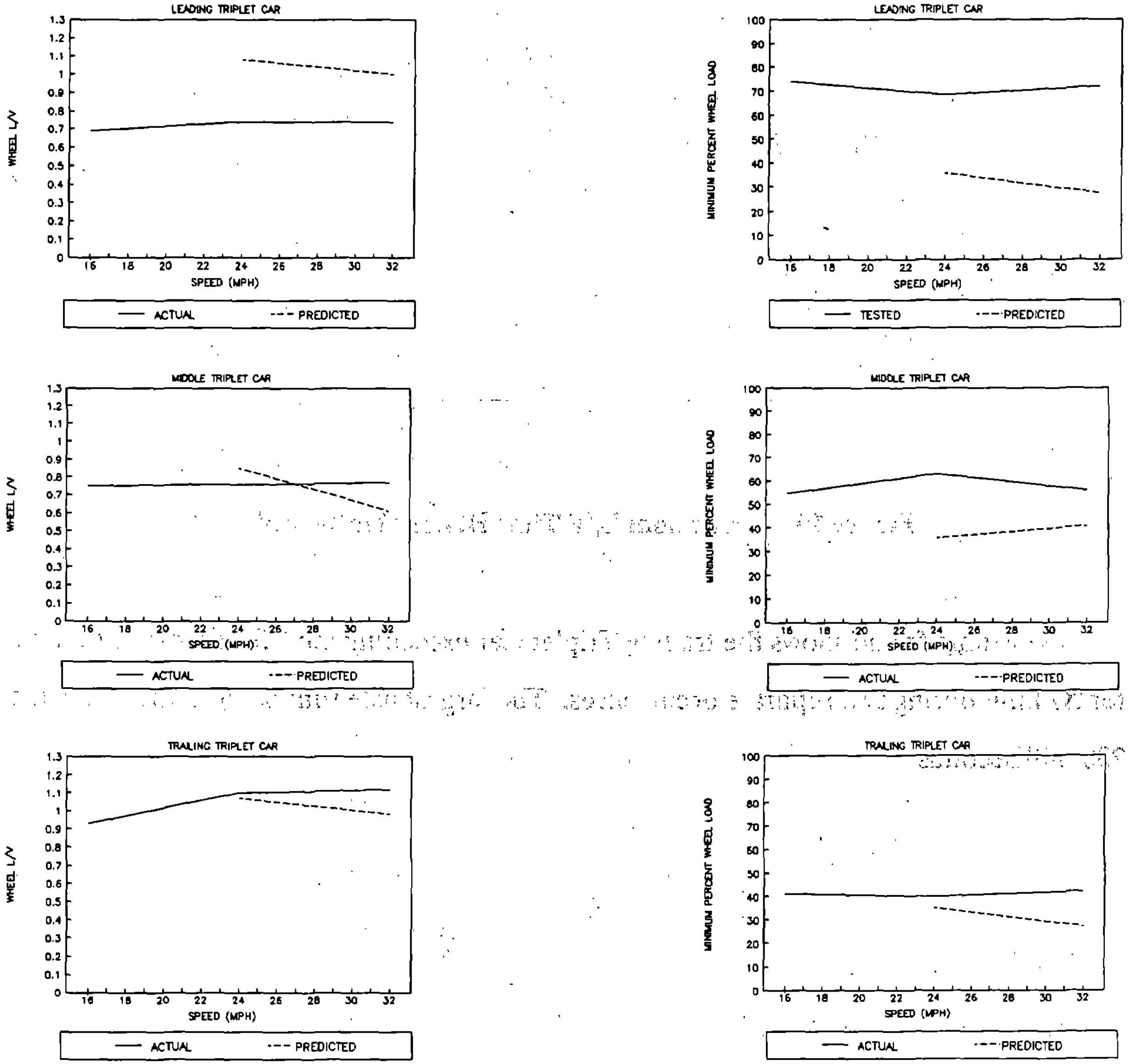

Figure 10.13 12-Degree Curve Exit Results Versus Predicted Wheel L/V and Minimum Percent Wheel Load

11.0 PHASE II TEST RESULTS

11.1 HUNTING

There were two criteria for the hunting test: (1) maximum axle sum L/V of 1.3 sustained for 50 milliseconds, and (2) maximum peak-to-peak lateral acceleration of 1.0 g sustained for 20 seconds, or any single occurrence greater than 1.5 g. The maximum test speed was limited to 60 mph at the request of the Air Force for the Phase II cars (leading Triplet, MLC, and trailing Triplet).

Table 11.1 is a tabulation of hunting test results for each car. The maximum lateral peak-to-peak car body acceleration was 1.49 g, which occurred on the leading Triplet Car at 60 mph. All other g levels over 1.0 g were either single occurrences, or were only sustained for 4 to 8 seconds. Although not exceeding Chapter XI criteria, the two Triplet Cars were noted as visibly hunting by the testing staff.

Table 11.1 Triplet Cars Hunting Test Results

SPEED (mph)	MAXIMUM P-P LATERAL ACCELERATION (g)	MAXIMUM AXLE SUM L/V
LEADING TRIPLET CAR		
30	.64	.41
40	.73	.27
50	.58	.45
60	1.49	.72
MLC		
30	.58	.16
40	.71	.18
50	.89	.31
60	1.12	.45
TRAILING TRIPLET CAR		
30	.24	.28
40	.34	.35
50	.45	.37
60	.66	.54

11.2 TWIST AND ROLL

Results were compared to the three Chapter XI criteria for the Twist and Roll Test. The maximum test speed was 60 mph.

Table 11.2 is a tabulation of pre-twist and roll vertical wheel force data for each car. This was used to determine the "static" wheel load used in the minimum vertical wheel load percent calculations for twist and roll criteria.

Table 11.2 Rolling Unperturbed Wheel Loads (kips)

SPEED (mph)	10	13	16	20	30	40	50	60	AVG	STD DEV	EST WEIGHT
FV1R :	22.35	22.36	22.84	22.50	23.05	23.08	23.03	22.95	22.77	.30	LEADING 399
FV1L :	26.87	26.78	26.70	26.95	26.85	27.57	27.72	27.25	27.09	.36	
FV2R :	37.21	37.21	37.09	36.93	36.74	36.92	36.91	36.78	36.97	.17	
FV2L :	35.47	35.48	35.75	35.49	35.60	35.47	35.64	35.53	35.55	.09	
FV3R :	38.34	38.30	38.49	37.80	38.03	38.66	38.19	38.13	38.24	.25	
FV3L :	38.64	38.53	38.43	39.08	38.72	38.08	37.81	38.30	38.45	.37	MLC 572
FV4R :	34.32	34.29	34.14	33.93	33.90	34.67	34.60	34.93	34.35	.34	
FV4L :	35.80	35.74	35.49	35.94	35.68	35.29	35.08	35.06	35.51	.31	
FV5R :	33.35	33.29	33.04	32.74	32.8	32.95	32.89	33.15	33.03	.21	
FV5L :	33.70	33.64	34.43	33.81	33.95	33.65	33.50	33.48	33.77	.29	
FV6R :	26.16	25.95	25.83	26.21	25.94	25.16	25.80	25.55	25.83	.32	TRAILING 405
FV6L :	24.79	24.95	25.38	24.77	24.59	24.40	25.02	24.10	24.75	.37	

To verify proper instrumented wheel set operation, vehicle weight was estimated from the vertical wheel loads. Since only one wheel set under the leading and trailing car was instrumented, the average wheel loads were multiplied by the number of wheel sets on the car. The MLC had four instrumented wheel sets, which were averaged and then multiplied by eight.

The weight of the leading and trailing Triplet Car as given by ATSF is 140,550 pounds. With the addition of 264,000 pounds from the concrete blocks, the total weight of each car became 404,550 pounds. This was a difference of 5,670 pounds or 1.4 percent of the total vehicle weight estimated for the leading car from instrumented wheel data, and 13,595 pounds or 2.4 percent of the total vehicle weight estimated for the MLC from instrumented wheel set data, and the trailing car was nearly equal to total vehicle weight.

Table 11.3 is a tabulation of the minimum percent wheel load, roll angle, and axle sum L/V for the leading Triplet Car. Lower center roll for the leading car was determined during modal testing to be 0.88 Hz, which corresponds to 23 mph. The severity of the reaction near resonance (20 mph) was repressed due to the difference between the axle spacing length of the car and the 39-foot perturbation cycle. The cars were not tested at 23 mph, but were tested through a range between 10 mph to 60 mph. The leading car performed well within Chapter XI criteria.

Table 11.3 Leading Triplet Car (ATSF 90006) Twist and Roll Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V
10	59	2.0	.29
14	61	0.7	.29
16	58	--	.33
20	55	0.9	.30
30	60	1.4	.33
40	59	1.3	.34
50	64	1.0	.36
60	68	1.2	.35

Table 11.4 is a tabulation of the minimum percent wheel load, roll angle, and axle sum L/V for the MLC. The lower center roll of the MLC was found to be 0.5 Hz from lab testing, which corresponds to 13 mph on the 39-foot wavelength perturbations. The severity of the reaction at resonance (13 mph) was repressed due to the difference between the axle spacing length of the MLC and the 39-foot perturbation cycle. The MLC was tested through a range of 10 mph to 60 mph. The MLC performed well within Chapter XI criteria.

Table 11.4 MLC Twist and Roll Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V
10	64	0.8	.18
13	61	1.9	.17
16	62	1.1	.20
20	66	1.5	.20
30	66	1.3	.18
40	65	1.0	.20
50	63	0.7	.34
60	55	1.1	.45

Table 11.5 is a tabulation of the minimum percent wheel load, roll angle, and axle sum L/V for the trailing Triplet Car. Lower center roll for the car was determined during modal testing to be 0.88 Hz, which corresponds to 23 mph on the 39-foot wavelength perturbations. The severity of the reaction near resonance (20 mph) was repressed due to the difference between the axle spacing length of the car and the 39-foot perturbation cycle. The trailing car performed well within the Chapter XI criteria.

Table 11.5 Trailing Triplet Car (ATSF 90007) Twist and Roll Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V
10	57	--	.34
13	58	0.6	.38
16	59	--	.39
20	58	0.8	.52
30	54	2.0	.35
40	50	1.5	.46
50	56	1.2	.46
60	52	1.2	.49

11.3 PITCH AND BOUNCE

Tables 11.6, 11.7, and 11.8 are tabulations of the minimum percent vertical wheel loads for the pitch and bounce test runs. The two Triplet Cars and the MLC performed within Chapter XI criteria.

Table 11.6 Leading Triplet Car (ATSF 90006) Pitch and Bounce Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	WHEEL AND LOCATION
30	74	1 Left
40	70	1 Left
50	74	1 Left
60	68	1 Left

Table 11.7 MLC Pitch and Bounce Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	WHEEL
30	75	4 Right
40	76	4 Right
50	76	4 Left
60	69	5 Right

Table 11.8 Trailing Triplet Car (ATSF 90007) Pitch and Bounce Results

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	WHEEL
30	79	6 Right
40	75	6 Right
50	73	6 Right
60	72	6 Right

Figure 11.1 compares pitch and bounce test results to the Chapter XI limit.

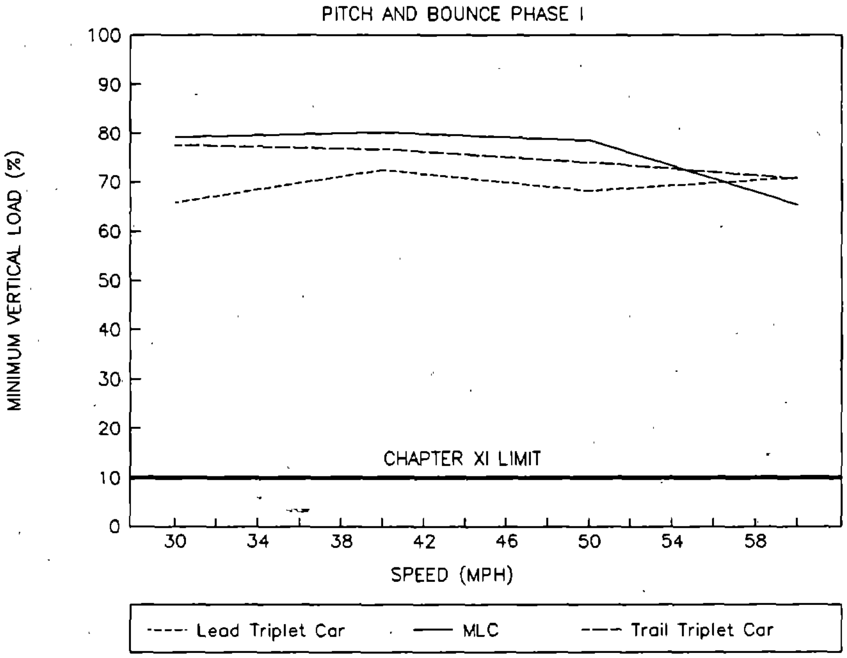

Figure 11.1 Pitch and Bounce Results Versus Chapter XI

11.4 YAW AND SWAY

To obtain truck side L/V ratios, the leading truck of each span bolster on the MLC was configured with two instrumented wheel sets. The maximum test speed was 60 mph.

Table 11.9 is a tabulation of the maximum axle sum and truck side sum L/V ratios for the yaw and sway test runs for the MLC. The highest axle sum L/V induced during yaw and sway testing was 0.94 at 50 mph and the highest truck side sum produced was a 0.48 at 60 mph. Both values are within the Chapter XI criteria.

Table 11.9 Yaw and Sway Test Results

SPEED (mph)	AXLE SUM L/V	TRUCK SIDE SUM L/V
30	0.69	0.33
40	0.88	0.35
50	0.94	0.45
60	0.93	0.48

11.5 TURNOUT AND CROSSOVER

Chapter XI guidelines for wheel L/V of 0.8 and axle sum L/V of 1.3 sustained for 50 milliseconds were used for the turnout and crossover tests.

Table 11.10 summarizes the turnout and crossover results for wheel L/V and axle sum L/V for each car. The maximum L/V, of the trailing Triplet Car, exceeded the axle sum guideline with a 1.35 at 10 mph in the turnout. Crossover L/V values were considerably below the 0.8 and 1.3 wheel and axle sum L/V criteria.

Table 11.10 Turnout and Crossover Results

TEST	SPEED (mph)	MAXIMUM WHEEL L/V	MAXIMUM AXLE SUM L/V	mSEC OVER 1.3
LEADING TRIPLET CAR				
Turnout	10	0.72	1.22	--
Turnout	15	0.73	1.22	--
Crossover	15	.45	0.78	--
Crossover	25	0.53	0.89	--
Crossover	35	0.48	0.83	--
MLC				
Turnout	10	0.68	1.16	--
Turnout	15	0.65	1.18	--
Crossover	15	0.34	0.68	--
Crossover	25	0.46	1.04	--
Crossover	35	0.48	0.90	--
TRAILING TRIPLET CAR				
Turnout	10	0.80	1.35	40
Turnout	15	0.79	1.28	--
Crossover	15	0.47	0.80	--
Crossover	25	0.54	0.94	--
Crossover	35	0.60	1.04	--

11.6 DYNAMIC CURVING

Before testing, predictions were made using the TDM. The test was performed in both the clockwise and counterclockwise directions. Prior to Phase II dynamic curving the two extra IITRI 36-inch instrumented wheel sets installed for Phase I dynamic curving were removed.

Table 11.11 is a tabulation of the leading Triplet Car results and predictions for the clockwise direction. A minimum wheel load of 25 percent occurred at 30 and 32 mph. The maximum roll angle of 2.4 degrees peak-to-peak occurred at 32 mph. Wheel and axle sum L/V both had peak values at 22 mph of 0.71 and 1.21, respectively. The leading Triplet Car performed within Chapter XI criteria.

Table 11.11 Leading Triplet Car Dynamic Curving Results Clockwise Direction

SPEED (mph)	MINIMUM VERTICAL Wheel Load %		ROLL ANGLE (Degrees)	AXLE SUM L/V		WHEEL L/V
	ACTUAL	PRED		ACTUAL	PRED	
10	56	--	0.4	1.06	--	.65
12	58	69	--	--	1.30	.63
14	58	71	0.5	1.10	1.27	.67
16	58	70	0.6	1.11	1.25	.63
18	58	70	0.6	1.16	1.25	.67
20	62	72	0.6	1.19	1.25	.70
22	65	70	0.8	1.21	1.28	.71
24	58	68	1.0	1.18	1.23	.68
26	53	71	1.6	1.08	1.20	.61
28	40	65	--	1.12	1.27	.62
30	25	61	2.0	1.03	1.33	.63
32	25	58	2.4	0.94	1.27	.61

Table 11.12 is a tabulation of the MLC results and predictions for the clockwise direction. A minimum wheel load of 60 percent occurred at 32 mph. The maximum roll angle of 1.6 degrees peak-to-peak occurred at 22 and 24 mph. Wheel and axle sum L/V both had peak values at 22 mph of 0.73 and 1.23, respectively. The MLC performed within Chapter XI criteria.

Table 11.12 MLC Dynamic Curving Results Clockwise Direction

SPEED (mph)	MINIMUM VERTICAL Wheel Load %		ROLL ANGLE (Degrees)	AXLE SUM L/V		WHEEL L/V
	ACTUAL	PRED		ACTUAL	PRED	
10	53	--	0.8	1.12	--	.65
12	53	62	--	1.11	1.33	.65
14	56	62	0.6	1.16	1.35	.68
16	54	63	0.8	1.16	1.20	.69
18	60	68	1.2	1.22	1.18	.71
20	60	73	1.4	1.17	1.17	.68
22	61	77	1.6	1.23	1.15	.73
24	59	80	1.6	1.19	1.13	.69
26	51	79	--	1.19	1.05	.71
28	51	70	1.5	1.10	1.07	.62
30	53	64	1.2	1.10	1.05	.62
32	47	60	1.0	1.02	1.00	.57

Table 11.13 is a tabulation of the trailing Triplet Car dynamic curving results and predictions for the clockwise direction. A minimum wheel load of 32 percent occurred at 32 mph. Roll angle steadily increased to a maximum of 2.0 degrees peak-to-peak at 32 mph. Wheel L/V had a peak value of 0.8 at both 28 and 30 mph. Axle sum L/V exceeded Chapter XI criteria of 1.3 at 26 and 30 mph with a 1.31 and 1.32 respectively, but neither exceeded the 50 millisecond criteria.

Table 11.13 Trailing Triplet Car Dynamic Curving Results Clockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %		ROLL ANGLE (Degrees)	AXLE SUM L/V		mSEC OVER 1.3	WHEEL L/V
	ACTUAL	PRED		ACTUAL	PRED		
10	62	--	0.5	1.18	--	--	.68
12	62	68	0.5	1.21	1.29	--	.71
14	62	71	0.6	--	1.26	--	.70
16	63	70	0.7	1.24	1.24	--	.72
18	60	70	0.5	1.23	1.24	--	.74
20	63	72	0.7	1.27	1.24	--	.75
22	58	73	0.8	1.30	1.22	--	.77
24	58	69	0.9	1.28	1.24	--	.77
26	56	72	1.3	1.31	1.21	10	.78
28	54	65	1.8	1.30	1.27	--	.80
30	41	62	1.8	1.32	1.32	10	.80
32	32	58	2.0	1.27	1.28	--	.76

Figure 11.2 shows a comparison of axle sum L/V versus the TDM predicted axle sum L/V and a comparison of minimum percent vertical wheel load versus predicted minimum percent vertical wheel loads.

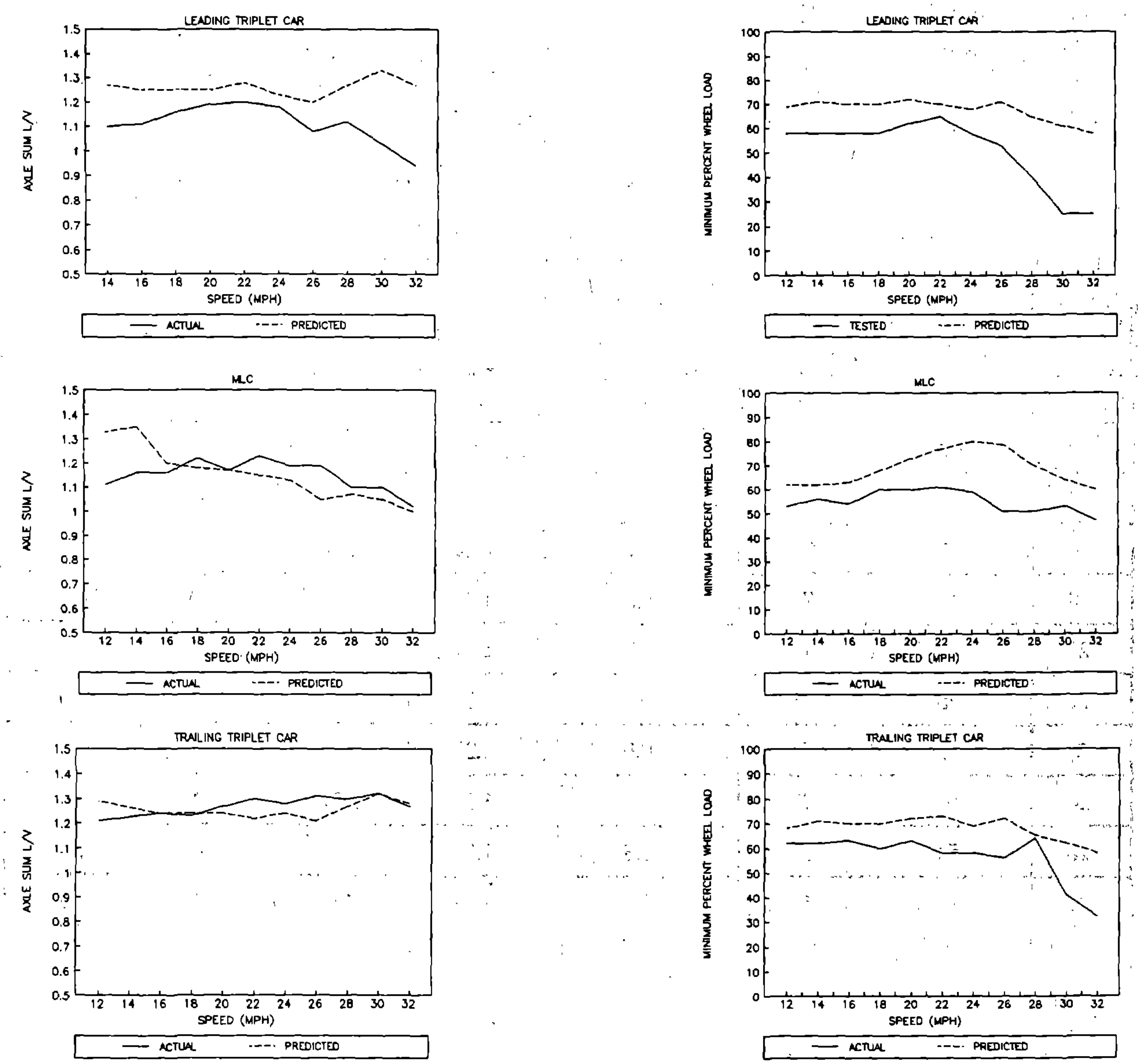

Figure 11.2 Dynamic Curving Results for Predicted Axle Sum L/V and Minimum Percent Vertical Wheel Load

Table 11.14 is a tabulation of the leading Triplet Car dynamic curving results and predictions for the counterclockwise direction. Wheel unloading steadily increased with speed until a minimum of 40 percent of the static wheel load was reached at 32 mph. Roll angle also increased with speed, having a maximum peak-to-peak roll angle of 2.0 degrees at 32 mph. The maximum wheel L/V of 0.59 occurred at 26 mph. The maximum axle sum of 1.27 occurred at 26, 28, and 30 mph. The leading Triplet Car performed within Chapter XI criteria.

Table 11.14 Leading Triplet Car Dynamic Curving Results
Counterclockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V	WHEEL L/V
10	58	0.3	1.21	.69
12	56	0.5	1.22	.70
14	54	0.3	1.26	.73
16	58	--	1.25	.74
18	60	0.2	1.19	.70
20	56	--	--	.70
22	58	0.3	1.25	.77
24	60	0.9	1.25	.78
26	54	1.3	1.27	.79
28	48	1.6	1.27	.78
30	42	1.3	1.27	.78
32	40	2.0	1.21	.73

Table 11.15 is a tabulation of the MLC dynamic curving results for the counterclockwise direction. Wheel unloading steadily increased with speed until a minimum of 37 percent of the static wheel load was reached at 32 mph. Car body roll peaked at 30 mph with a roll angle of 1.8 degrees peak-to-peak. The maximum wheel L/V of 0.80 occurred at 10 mph. The maximum axle sum L/V was 1.31 at 10 mph and lasted for 30 milliseconds. The MLC performed within Chapter XI criteria.

Table 11.15 MLC Dynamic Curving Results Counterclockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V	mSEC OVER 1.3	WHEEL L/V
10	58	0.5	1.31	30	.80
12	58	1.3	1.24	--	.75
14	57	1.3	1.26	--	.76
16	59	1.2	1.24	--	.75
18	65	1.3	1.23	--	.74
20	68	1.1	--	--	.71
22	63	1.2	1.21	--	.72
24	61	1.5	1.19	--	.71
26	53	1.5	1.19	--	.66
28	49	1.4	1.13	--	.65
30	48	1.8	1.13	--	.63
32	37	1.1	1.12	--	.61

Table 11.16 is a tabulation of the trailing Triplet car results for the counterclockwise direction. Wheel unloading steadily increased with speed until a minimum of 32 percent of the static wheel load was reached at 32 mph. Roll angle also increased with speed having a maximum peak-to-peak roll angle of 2.6 degrees at 32 mph. The maximum wheel L/V of 0.75 occurred at 12 mph. The maximum axle sum occurred twice at underbalance speeds and once at an overbalance speed. The maximum of 1.36 occurred at 18 mph and exceeded 1.3 for 50 milliseconds. The trailing Triplet car did not exceed Chapter XI criteria.

Table 11.16 Trailing Triplet Car Dynamic Curving Results
Counterclockwise Direction

SPEED (mph)	MINIMUM VERTICAL WHEEL LOAD %	ROLL ANGLE (Degrees)	AXLE SUM L/V	mSEC OVER 1.3	WHEEL L/V
10	65	0.3	1.33	30	.75
12	58	--	1.28	--	.79
14	61	0.5	1.25	--	.71
16	62	0.6	1.26	--	.72
18	62	0.6	1.36	50	.78
20	59	0.6	--	--	.73
22	57	0.6	1.23	--	.70
24	56	0.7	1.18	--	.68
26	57	1.2	1.26	--	.73
28	56	1.7	1.33	20	.75
30	38	2.1	1.25	--	.75
32	32	2.6	1.20	--	.69

11.7 CONSTANT CURVING

Table 11.17 is a tabulation of the 7.5-degree curve entry results for each car. In the counterclockwise direction the consist was exiting the 12-degree curve then immediately entering the 7.5-degree curve, which is a reverse curve. All cars negotiated the curve entry within Chapter XI guidelines.

Table 11.17 7.5-Degree Curve Entry Results -- CW and CCW Direction

SPEED (mph)	DIR	MAXIMUM WHEEL L/V	MINIMUM WHEEL LOAD %	AXLE SUM L/V
LEADING TRIPLET CAR				
14	CW	.57	60.9	1.06
24	CW	.53	64.9	.80
32	CW	.61	65.5	1.11
16	CCW	.65	67.9	1.15
24	CCW	.76	65.0	1.24
32	CCW	.70	62.4	1.2
MLC				
14	CW	.48	64.6	--
24	CW	.42	66.5	.89
32	CW	.41	55.4	.81
16	CCW	.57	68.0	.97
24	CCW	.48	71.2	.84
32	CCW	.43	63.7	.77
TRAILING TRIPLET CAR				
14	CW	.60	56.7	1.00
24	CW	.55	58.5	1.17
32	CW	.49	40.6	.96
16	CCW	.67	60.0	1.14
24	CCW	.62	59.6	1.11
32	CCW	.60	51.8	1.00

Table 11.18 summarizes the 7.5-degree steady state curving results for each car. The higher wheel L/V ratios in the counterclockwise direction are probably due to the trucks being improperly aligned after exiting the 12-degree curve. All cars negotiated the curve within Chapter XI guidelines.

Table 11.18 7.5-Degree Steady State Results -- CW and CCW Direction

SPEED (mph)	DIR	MAXIMUM WHEEL L/V	95 % WHEEL L/V	MAXIMUM AXLE SUM L/V	95 % AXLE SUM L/V
LEADING TRIPLET CAR					
14	CW	.46	.35	.84	.70
24	CW	.45	.32	.80	.62
32	CW	.43	.34	.77	.66
14	CCW	.69	.57	1.17	1.00
24	CCW	.70	.56	1.17	.99
32	CCW	.66	.55	1.07	.96
MLC					
14	CW	.48	.48	.91	.70
24	CW	.68	.33	.89	.64
32	CW	.49	.33	.90	.62
14	CCW	.54	.39	.95	.71
24	CCW	.50	.37	.91	.69
32	CCW	.48	.33	.88	.61
TRAILING TRIPLET CAR					
14	CW	.69	.49	1.21	.91
24	CW	.64	.50	1.17	.90
32	CW	.69	.49	1.24	.92
14	CCW	.70	.52	1.23	.95
24	CCW	.68	.50	1.16	.92
32	CCW	.64	.48	1.10	.88

Table 11.19 summarizes the 7.5-degree curve exit test results for each car. All cars negotiated the curve exit within Chapter XI guidelines.

Table 11.19 7.5-Degree Curve Exit Results -- CW and CCW Direction

SPEED (mph)	DIR	WHEEL L/V	MINIMUM WHEEL LOAD %	AXLE SUM L/V
LEADING TRIPLET CAR				
14	CW	.51	75.3	.93
24	CW	.51	73.9	.90
32	CW	.49	72.5	.93
16	CCW	.55	68.8	.96
24	CCW	.53	58.6	.93
32	CCW	.58	60.1	.98
MLC				
14	CW	.52	70.7	.75
24	CW	.41	69.9	.69
32	CW	.31	58.5	.60
16	CCW	.50	57.0	.89
24	CCW	.45	69.6	.85
32	CCW	.40	56.3	.79
TRAILING TRIPLET CAR				
14	CW	.57	62.3	1.00
24	CW	.45	65.0	.80
32	CW	.56	64.5	.98
16	CCW	.66	45.4	1.16
24	CCW	.63	47.8	1.10
32	CCW	.60	58.3	1.02

Table 11.20 summarizes the 12-degree curve entry test results for each car. All cars negotiated the curve entry within Chapter XI guidelines; however, the trailing Triplet Car had a wheel load of 12.5 percent at 32 mph when entering the bunched spiral. This is within 2.5 percent or 626 pounds of Chapter XI criteria. Clockwise operation will result in curve entry on the normal spiral. Counterclockwise operation will result in curve entry on the bunched spiral.

Table 11.20 12-Degree Curve Entry Results -- CW and CCW Direction

SPEED (mph)	DIR	WHEEL L/V	PRED WHEEL L/V	MINIMUM WHEEL LOAD %	PRED WHEEL LOAD %	AXLE SUM L/V
LEADING TRIPLET CAR						
14	CW	.72	.74	71	38	1.20
24	CW	.69	.72	65	34	1.14
32	CW	.77	.72	54	21	1.19
16	CCW	.67	--	71	--	1.12
24	CCW	.59	--	61	--	1.12
32	CCW	.60	--	51	--	1.05
MLC						
14	CW	.67	.62	54	43	1.14
24	CW	.64	.47	62	62	1.08
32	CW	.63	.43	49	61	1.08
16	CCW	.66	--	62	--	1.15
24	CCW	.58	--	55	--	1.08
32	CCW	.53	--	44	--	.94
TRAILING TRIPLET CAR						
14	CW	.65	.73	69	38	1.17
24	CW	.58	.73	64	35	1.10
32	CW	.67	.72	56	21	1.15
16	CCW	.67	--	34	--	1.15
24	CCW	.66	--	21	--	1.13
32	CCW	.63	--	13	--	1.11

Figure 11.3 shows a comparison of wheel L/V versus the TDM predicted wheel L/V and a comparison of minimum percent vertical wheel load versus predicted minimum percent vertical wheel load for the 12-degree curve entry.

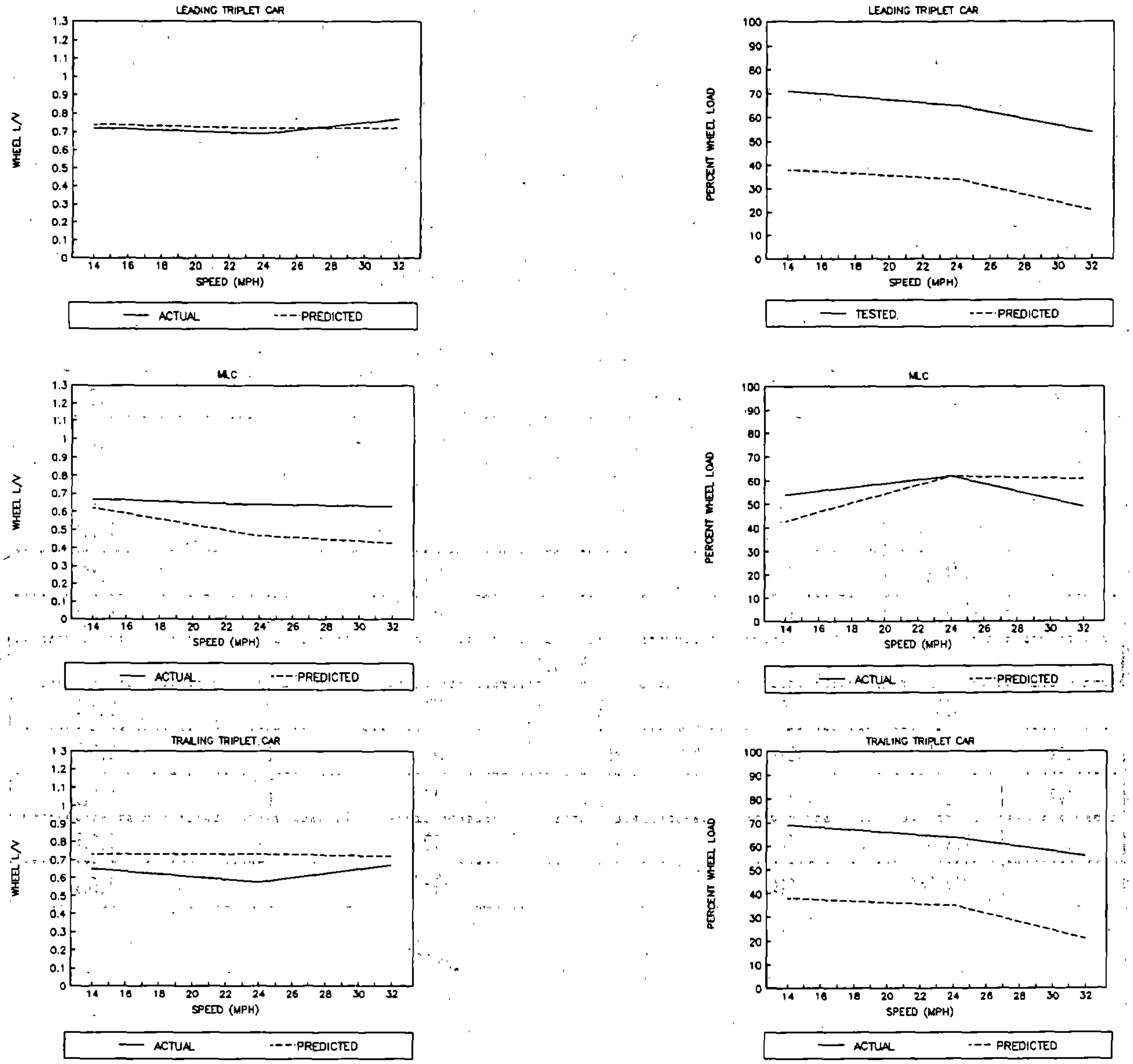

Figure 11.3 12-Degree Curve Entry Results Versus Predicted Wheel L/V and Predicted Minimum Percent Vertical Wheel Load

Table 11.21 summarizes the 12-degree curve steady state test results for each car. The trailing Triplet Car had an axle sum of 1.36 in the counterclockwise direction which exceeded 1.3 for 50 milliseconds. The trailing Triplet car maximum axle sum L/V 95 percentile value of 1.13 at 14 mph was well below the Chapter XI criteria of 1.3. The MLC also had a maximum axle sum 95 percentile value of 1.13. All three cars had 95 percentile values well within Chapter XI limits.

Table 11.21 12-Degree Steady State Results -- CW and CCW Direction

SPEED (mph)	DIR	MAXIMUM WHEEL L/V	95 % WHEEL L/V	PRED WHEEL L/V	AXLE SUM L/V			PRED SUM L/V
					PEAK	mSEC OVER 1.3	95 %	
LEADING TRIPLET CAR								
14	CW	.67	.58	.52	1.13	--	1.04	1.03
24	CW	.67	.58	.48	1.14	--	1.03	.96
32	CW	.66	.57	.47	1.16	--	1.04	.92
14	CCW	.70	.56	--	1.23	--	1.03	--
24	CCW	.68	.55	--	1.18	--	1.02	--
32	CCW	.65	.52	--	1.11	--	.93	--
MLC								
14	CW	.65	.57	.54	1.11	--	1.06	.96
24	CW	.55	.46	.42	1.02	--	.91	.84
32	CW	.54	.49	.42	.99	--	.93	.78
14	CCW	.76	.64	--	1.29	--	1.13	--
24	CCW	.73	.58	--	1.25	--	1.06	--
32	CCW	.59	.50	--	1.11	--	.95	--
TRAILING TRIPLET CAR								
14	CW	.59	.50	.52	1.11	--	.98	1.01
24	CW	.54	.49	.48	1.05	--	.92	.96
32	CW	.57	.50	.47	1.06	--	.97	.92
14	CCW	.80	.64	--	1.36	50	1.13	--
24	CCW	.78	.61	--	1.31	25	1.09	--
32	CCW	.79	.59	--	1.32	25	1.07	--

Figure 11.4 shows a comparison of the wheel L/V versus the TDM predicted wheel L/V and a comparison of axle sum L/V versus predicted axle sum L/V for the 12-degree steady state curve.

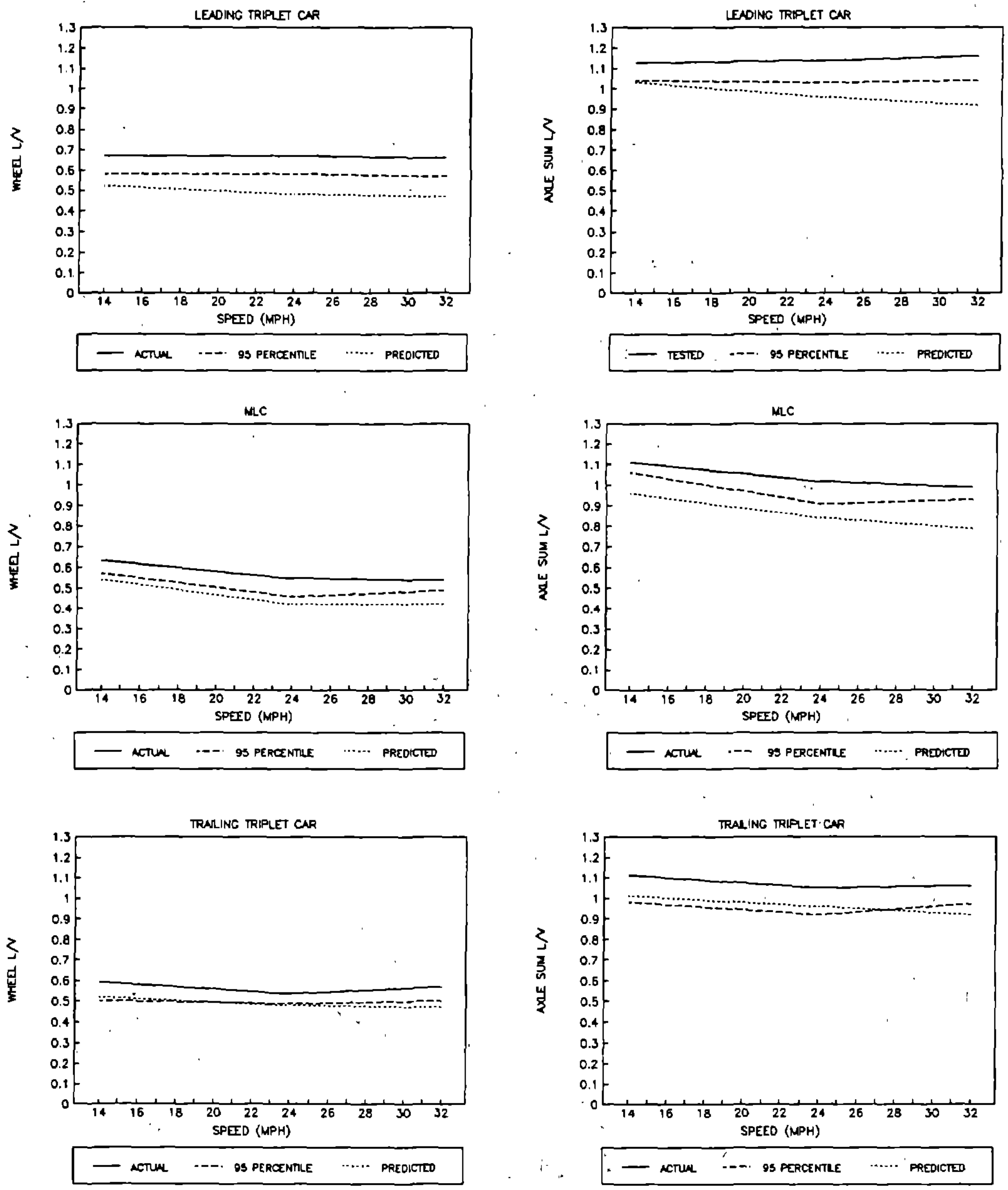

Figure 11.4 12-Degree Curve Steady State Results Versus Predicted Wheel L/V and Predicted Axle Sum L/V

Table 11.22 summarizes the 12-degree curve exit results for each car. The leading Triplet Car and MLC negotiated the curve exit within Chapter XI criteria in both the clockwise and counterclockwise directions. The trailing Triplet Car, however, exceeded Chapter XI criteria at underbalance, balance, and overbalance speeds when exiting the bunched spiral (clockwise operation).

Table 11.22 12-Degree Curve Exit Results

SPEED (mph)	DIR	WHEEL L/V		PRED WHEEL L/V	MINIMUM WHEEL LOAD %	PRED MINIMUM WHEEL LOAD %	AXLE SUM L/V	
		PEAK	mSEC OVER 0.8				PEAK	mSEC OVER 1.3
LEADING TRIPLET CAR								
14	CW	.62	--	1.08	72	36	1.17	--
24	CW	.63	--	1.00	62	28	1.14	--
32	CW	.64	--	1.19	64	34	1.13	--
16	CCW	.67	--	--	64	--	1.12	--
24	CCW	.60	--	--	55	--	1.17	--
32	CCW	.66	--	--	44	--	.93	--
MLC								
14	CW	.70	--	.44	46	62	1.16	--
24	CW	.55	--	.42	61	41	1.01	--
32	CW	.54	--	.56	53	41	1.02	--
16	CCW	.73	--	--	62	--	1.27	--
24	CCW	.69	--	--	63	--	1.23	--
32	CCW	.57	--	--	44	--	1.05	--
TRAILING TRIPLET CAR								
14	CW	1.27	2050	1.06	38	33	1.68	600
24	CW	1.12	225	.98	51	27	1.53	200
32	CW	.96	200	1.17	52	33	1.40	100
16	CCW	.79	--	--	62	--	1.28	--
24	CCW	.77	--	--	65	--	1.25	--
32	CCW	.74	--	--	54	--	1.22	--

Chapter XI states that no wheel L/V shall exceed 0.8 for greater than 50 milliseconds. The trailing Triplet Car exceeded multiple times with durations between 0.2 and 2.05 seconds. The trailing car also yielded an axle sum L/V of 1.68 with a duration of 600 milliseconds over 1.6; however, Chapter XI does not specify an axle sum limit for curve entry and exit. All cars performed within Chapter XI criteria in the counterclockwise direction, which is exiting a normal spiral.

Figure 11.5 is a time history plot of the trailing Triplet Car wheel L/V ratio during the 14 mph clockwise run.

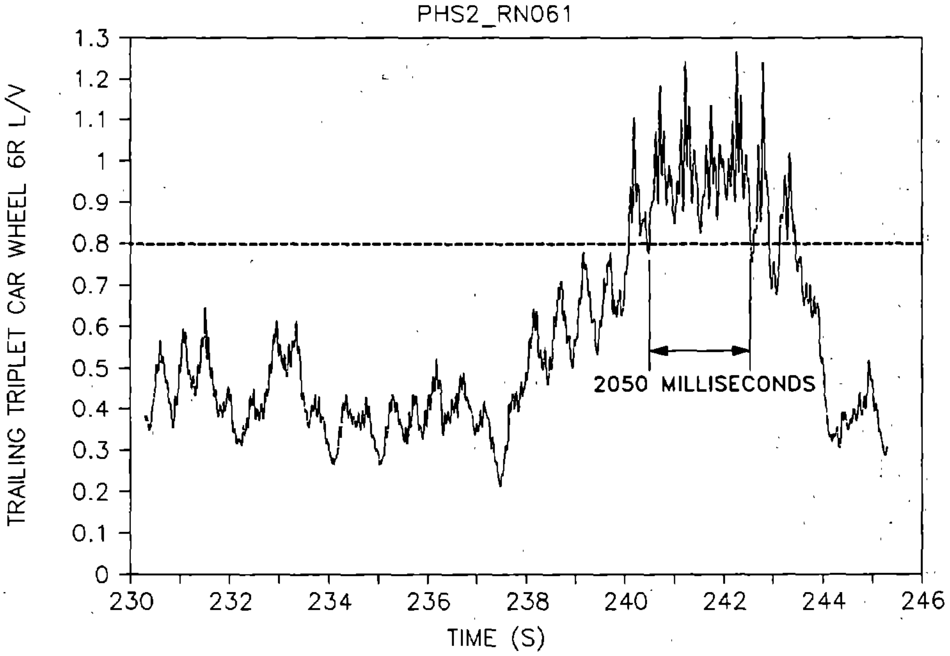

Figure 11.5 Time History Plot of the Trailing Triplet Car Wheel L/V

Any wheel L/V over 0.8 with a duration greater than 50 milliseconds is cause for concern. Wheel 6R had a maximum wheel L/V of 1.27 which lasted for over 2 seconds. An L/V of that magnitude and duration is considered severe. Testing was continued to further characterize the consist and to help validate the TDM.

Figure 11.6 is a time history plot of the trailing Triplet Car axle sum L/V during the 14 mph clockwise curve exit run.

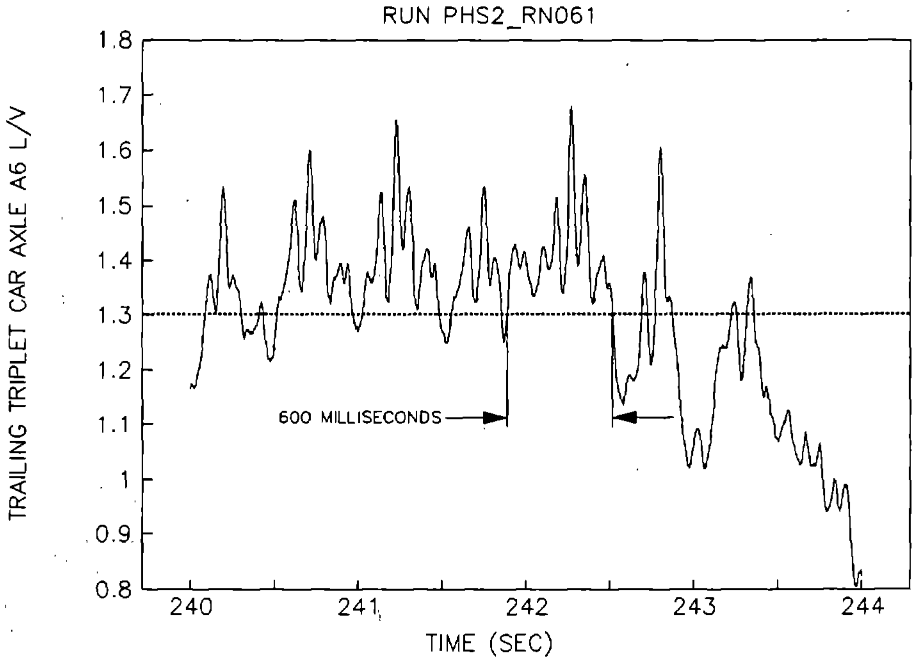

Figure 11.6 Time History Plot of the Trailing Triplet Car Axle Sum L/V

Axle 6 on the trailing car had repeated L/V ratios over 1.3 with some lasting up to 600 milliseconds.

Figure 11.7 shows a comparison of wheel L/V versus the TDM predicted wheel L/V and a comparison of minimum vertical wheel load versus predicted minimum vertical wheel load in percent for the 12-degree curve exit.

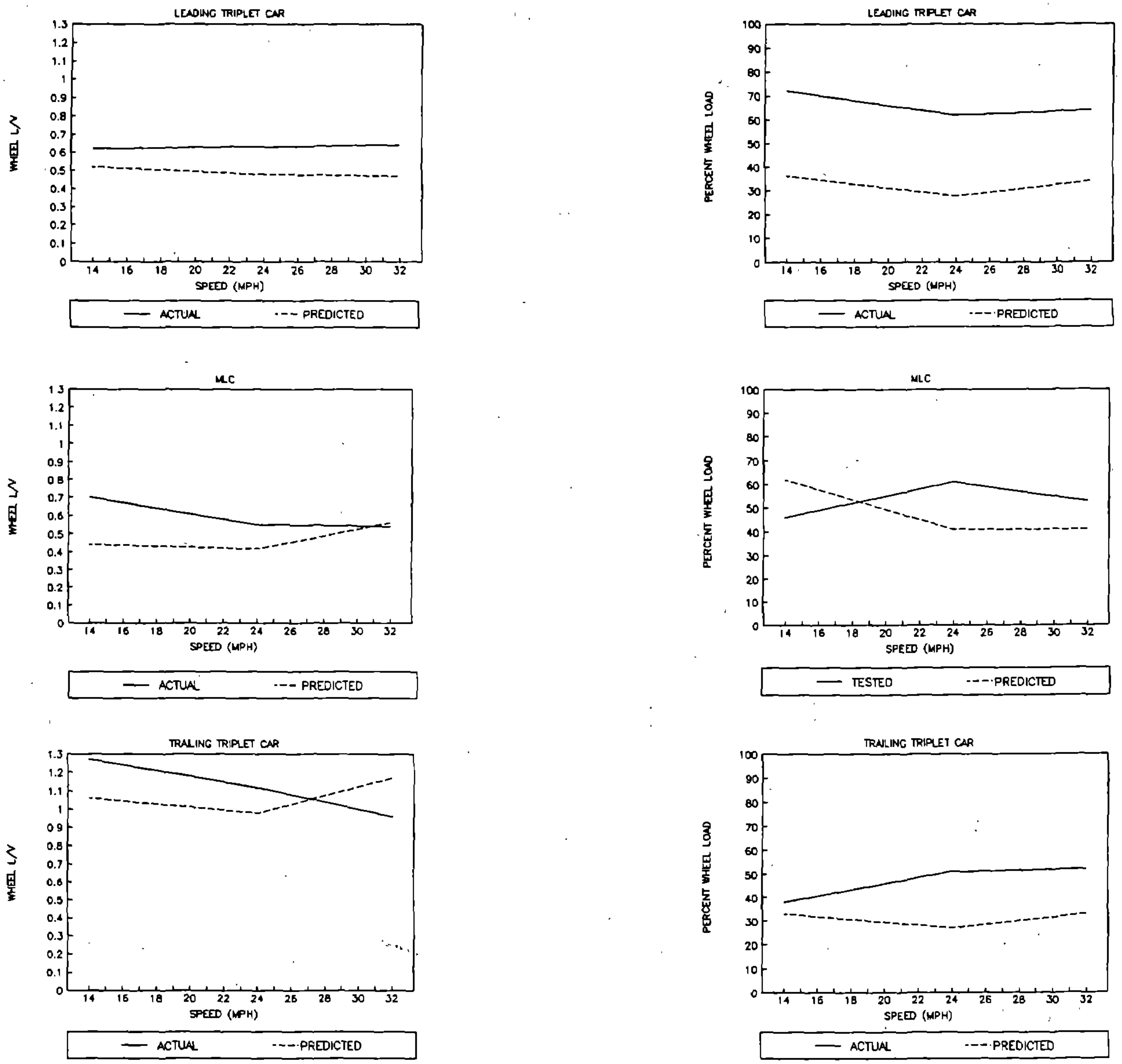

Figure 11.7 12-Degree Curve Exit Results Versus Predicted Wheel L/V and Predicted Minimum Percent Vertical Wheel Load

12.0 CONCLUSIONS

The following is a summary of service worthiness and Phases I and II test results.

12.1 SERVICE WORTHINESS/CURVE STABILITY

The Triplet Cars, which are all span bolster cars, were coupled together and exposed to buff and draft loads of 250,000 and 200,000 pounds, respectively, and exhibited no wheel lift or suspension separation during the Curve Stability Test.

12.2 PHASE I

For the purpose of validating the TDM, Chapter XI limiting criteria were used as a guideline. In order to better validate the TDM, testing was continued even after Chapter XI criteria had been exceeded during some tests.

1. **Hunting:**

   The leading Triplet Car performed within the Chapter XI criteria. The middle and trailing Triplet Cars exceeded Chapter XI lateral acceleration criteria with a 1.54 g and a 1.52 g peak-to-peak lateral acceleration, respectively. Chapter XI criteria states that no occurrence of greater than 1.5 g peak-to-peak is permitted. There were instances of sustained hunting for 8-14 seconds at g levels lower than the Chapter XI criteria of 1.0 g peak-to-peak.

2. **Pitch and Bounce:**

   All three cars performed within Chapter XI limits.

3. **Twist and Roll:**

All three cars performed within Chapter XI limits.

4. **Yaw and Sway:**

All three cars performed within Chapter XI limits.

5. **Turnout and Crossover:**

All three cars performed within guidelines for crossovers. An axle sum L/V of 1.32 lasting for 20 milliseconds was recorded at 10 mph during turnout testing.

6. **Dynamic Curving:**

During the Dynamic Curving Test, the leading and trailing Triplet Cars exceeded Chapter XI criteria in the counterclockwise direction, and the middle Triplet Car exceeded criteria in the clockwise direction.

7. **Constant Curving 7.5-Degree:**

All cars negotiated the 7.5-degree curve within Chapter XI limits.

8. **7.5-Degree Curve Entry and Exit:**

All cars negotiated the 7.5-degree curve entry and exit within Chapter XI limits.

9. **Constant Curving 12-Degree:**

All cars negotiated the 12-degree steady state curve within Chapter XI limits.

10. 12-Degree Curve Entry and Exit:

The leading Triplet Car exceeded Chapter XI limits in the 12-degree clockwise curve entry, which is a normal spiral, and the trailing Triplet Car exceeded during the 12-degree exit spiral (bunched spiral).

12.3 PHASE II

1. Hunting:

All cars performed within the Chapter XI criteria. There were instances of sustained hunting for 4-8 seconds at g levels lower than the Chapter XI criteria of 1.0 g peak-to-peak. Phase II hunting test runs were limited to 60 mph at direction of the Air Force.

2. Pitch and Bounce:

All three cars performed within Chapter XI limits.

3. Twist and Roll:

All three cars performed within Chapter XI limits.

4. Yaw and Sway:

All three cars performed within Chapter XI limits.

5. Turnout and Crossover:

All three cars performed within guidelines for crossovers. An axle sum L/V of 1.35 lasting for 40 milliseconds was recorded at 10 mph during turnout testing.

6. Dynamic Curving:

All cars performed within Chapter XI limits in both the clockwise and counter-clockwise directions.

7. **Constant Curving 7.5-Degree:**

All cars negotiated the 7.5-degree curve within Chapter XI limits.

8. **7.5-Degree Curve Entry and Exit:**

All cars negotiated the 7.5-degree curve entry and exit within Chapter XI limits.

9. **Constant Curving 12-Degree:**

All cars negotiated the 12-degree curve within Chapter XI limits.

10. **Constant Curving 12-Degree:**

All cars negotiated the 12-degree curve entry within Chapter XI limits. During curve exit, the trailing Triplet Car exceeded Chapter XI wheel and axle sum L/V criteria of 0.8 and 1.3 at underbalance, balance, and overbalance speeds. A maximum wheel L/V of 1.27 lasting for over two seconds, and a maximum axle sum L/V of 1.68 lasting for 600 milliseconds were recorded during the 14 mph run.

Chapter XI states that values better than the criteria outlined are regarded as indicating the likelihood of safe car performance. Twist and roll, pitch and bounce, and yaw and sway contain perturbations of 39-foot wavelengths. A car with 39- or 58-foot truck spacing would be most sensitive to such perturbations. The distance from the A-end span bolster center pin to the B-end span bolster center pin was 60 feet for the leading and trailing Triplet cars, and 55 feet for the middle Triplet Car. The 39-foot wavelength perturbation had little affect on any of the Triplet Cars. A wavelength of 39 feet was chosen to be most typical of excitation expected from commercial track. Perturbations of other wavelengths are possible, but less likely. Multiples of 55 or 60 feet will provide more input to the cars than the Chapter XI 39-foot wavelength.

In conclusion, the results that exceeded Chapter XI criteria observed during the coupled span bolster car tests are consistent with those observed in single car PKRG span bolster tests. Therefore, coupled operation with this short train did not result in noticeably degraded performance.

13.0 RECOMMENDATIONS

Proceed with 7.3.1 A testing. After completion of hunting, pitch and bounce, twist and roll, and yaw and sway, a comparison of the results should be made to the triplet test results. If 7.3.1 A results are significantly worse, special considerations should be made prior to curve testing. Among the considerations should be speed restrictions, added instrumentation, a test on a less severe curve, or possibly a design change to the car(s) that are not performing within Chapter XI limits.

APPENDIX A

SERVICE WORTHINESS TEST PROCEDURE

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-6000-TC
SERVICE WORTHINESS TEST

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-6000-TC
SERVICE WORTHINESS TEST

1.0 DESCRIPTION

This procedure outlines the sequence of steps to conduct Service Worthiness Tests on the Peacekeeper Rail Garrison Triplet Cars (TC). The Service Worthiness Test consists of the Curve Stability Test and Draft Gear Characterization.

1.1 INDEX

1.2 EQUIPMENT LIST

a.	1 ea	Generator, Portable Model 30KW
b.	1 ea	Instrumented Coupler (1,000,000)
c.	1 ea	Strain Guage, Daytronic 3270
d.	1 ea	X-Y Recorder
e.	4 st	Wheel Chocks
f.	1 ea	100-ton Hopper Car (modified)

g.	1 ea	Coupler Adapter (Squeeze Fixture)
h.	1 ea	Hewlett-Packard (HP)300 Series Data Acquisition System
i.	20	2702 Instrum Signal Conditioner
j.	1 ea	Western Graphic Strip Chart or Equivalent
k.	2 ea	Feeler Gauges
l.	3 ea	String Pot, +/- 10-inch Range

1.3 FIGURE LIST

1.4 TABLE LIST

None

1.5 REFERENCE LIST

None

1.6 ATTACHMENTS

1 Test Measurement List
2 Instrum 2702 Signal Conditioner Setup Procedure

NOTE

All personnel involved in the performance of this procedure or observing the test(s) will comply with the TTC Safety Rule Book.

2.0 CURVE STABILITY TEST

2.1 Test Setup

NOTE

The test cars will be in the loaded condition for the following test.

TASK NUMBER	PROCEDURE	QA INITIAL
2.1.1	Place the test cars in a consist as illustrated in Figure 2-1.	

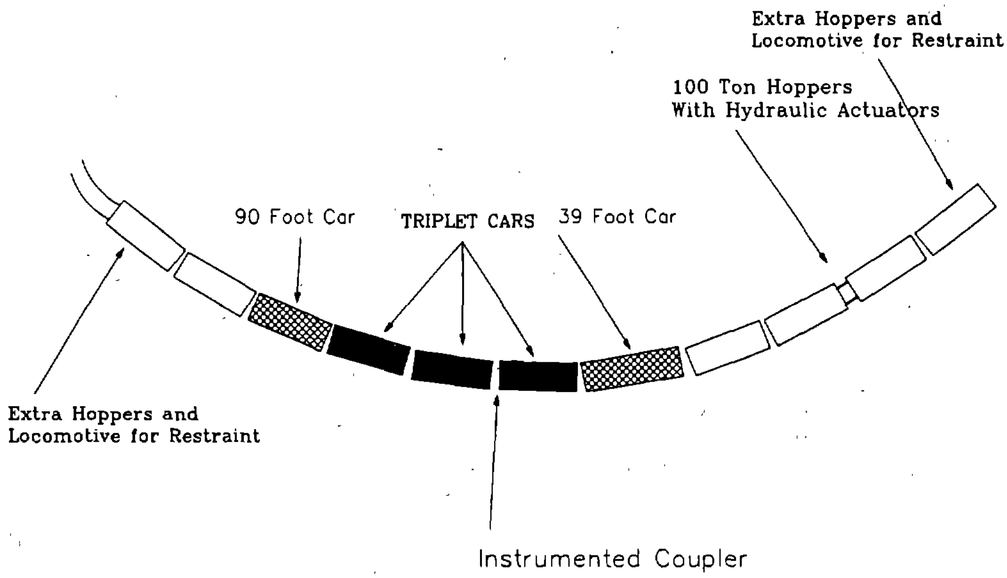

Figure 2-1 Curve Stability Test Facility

TASK NUMBER	PROCEDURE	QA INITIAL
2.1.2	The consist will be placed on the South Wye of the Urban Rail Building (URB) access track.	
2.1.3	Quality verify proper set up for the Curve Stability Test.	________

2.2 Instrumentation Installation, Calibration and Operation

TASK NUMBER	PROCEDURE	QA INITIAL
2.2.1	Refer to the Test Measurement List (Attachment 1) for instrumentation installation location.	
2.2.2	Refer to Procedure PKRG-3100 for completing the Test Configuration Data Sheet.	
2.2.3	Instrumented Coupler Setup:	
2.2.3.1	Monitor the signal conditioner excitation to the transducer for a minimum of five minutes.	
2.2.3.2	Verify that the 3270 indicator switch, located on the rear panel, is set to 20,000.	________
2.2.3.3	Verify that the display switches 1 through 5 are closed.	________
2.2.3.4	Verify that the display switch 6 is open.	________
2.2.3.5	Adjust the course and then the fine balance potentiometers for 0.00 on the display indicator.	
2.2.3.6	Calculate shunt calibration reading using the following formula: $X = \frac{2500 R_b}{K(R_c + R_b)}$ X = Indicator Reading R_b = Bridge Resistance (typical 350 ohm) K = MV/V Sensitivity R_c = Shunt Cal Resistor Value (29.88 K typical) Typical X (96.5 % or 193 K)	

2.2.3.7 Adjust the course and then the fine span to the value calculated in Step 2.2.3.6.

2.2.3.8 Repeat Steps 2.2.3.5 and 2.2.3.6 as necessary.

2.2.4 Strip chart setup

2.2.4.1 Balance tranceducer while zero load on coupler.

2.2.4.2 Set chart speed to 50mm/min

2.2.4.3 Patch instrumented coupler into strip chart.

2.2.4.4 Quality verify instrumentation installation and calibration is complete. ________

2.3 Curve Stability Testing

TASK NUMBER	PROCEDURE	QA INITIAL
2.3.1	Preload to maximum attainable and set chocks.	
2.3.2	Start strip chart.	
2.3.2.1	With the test consist positioned at the Curve Stability Test site as outlined in Section 2.1 and the instrumentation operating as outlined in Section 2.2, begin applying a buff load (compressive) using the actuators illustrated in Figure 2-1.	
2.3.3	Using strain gage conditioner/indicator, read force values.	

2.3.4 Continue applying the buff load until a maximum load of 100,000 pounds is applied.

2.3.5 The test car will be held in place for a 20 second sustained duration while under the maximum load (+5000 - 0 pounds).

2.3.6 The test car will be monitored for the following conditions: wheel lift, any separation of the trucks and car body.

2.3.7 Check wheel lift with feeler gauges. Wheel lift should not exceed 1/8 inches when measured 2 5/8 inches from the wheel rim face at the inside rail of curve for buff and outside rail for draft.

2.3.8 Repeat Steps 2.3.2 through 2.3.4.1 applying buff load to 250,000 pounds. ______

2.3.9 Repeat Steps 2.3.1 through 2.3.4.2 using draft (tensile) loads, but only apply load to 200,000 pounds.

2.3.10 Quality verify that the Curve Stability Test is complete. ______

3.0 DRAFT GEAR CHARACTERIZATION

3.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
3.1.1	Place the cars in a consist as illustrated in Figure 3-1	

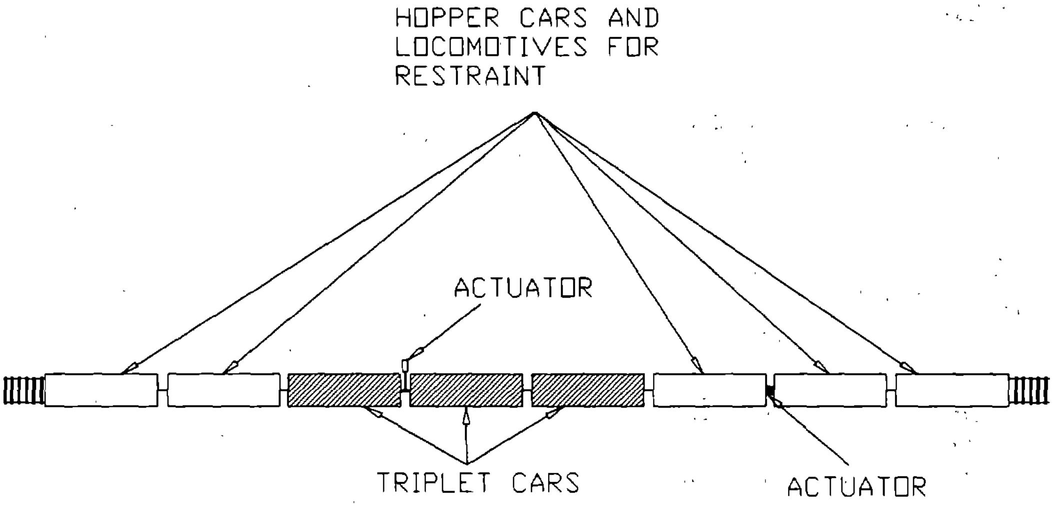

Figure 3-1 Draft Gear Characterization Test Facility

3.1.2 The consist will be placed on the north end of the Perturbed Test Track.

3.1.3 Quality verify proper setup for the Draft Gear Characterization Test. _____

3.2 Instrumentation Installation, Calibration and Operation

TASK NUMBER	PROCEDURE	QA INITIAL
3.2.1	Perform Steps 2.2.1 through 2.2.4.8.	
3.2.2	Install string pots so as to measure the lateral deflection of the coupler and the longitudinal deflection of each adjacent triplet car.	
3.2.3	Quality verify instrumentation installation and calibration is complete.	_____

3.3 Draft Gear Characterization Testing

TASK NUMBER	PROCEDURE	QA INITIAL
3.3.1	With test car positioned as outlined in Section 3.1 and the instrumentation operating as outlined in Section 3.2, physically measure coupler distance from striker and record below.	
3.3.2	Begin applying a buff (compressive) load.	
3.3.3	Hold buff load at 300,000 pounds, at which time, begin applying a lateral load to the coupler until a maximum load of 15,000 pounds is reached.	______
3.3.4	During lateral force application, start data aquisition system, be sure record time is long enough to record forces up to 15,000 pounds.	______
3.3.5	Release lateral and longitudinal forces.	______
3.3.6	Rebunch train to original buff load.	______
3.3.7	Physically measure coupler distance from side of striker and record.	______
3.3.8	Repeat Steps 3.3.1 through 3.3.7 for a compressive load of 50,000, 100,000, and 200,000 pounds.	______
3.3.9	Quality verify that the Draft Gear Characterization Test is complete.	______

4.0 QUALITY VERIFICATION

TASK NUMBER	PROCEDURE	QA INITIAL
4.1	Quality verify that PKRG 6000-TC is complete and closed.	
4.2	Authorized QA signature ______________________________.	

ATTACHMENT 1

TRIPLET CAR
CHAPTER XI SERVICE WORTHINESS
TEST MEASUREMENT LIST

MEAS CODE	DESCRIPTION AND LOCATION	TRANS TYPE	MEAS RANGE	TEST
LCFI	Longitudinal Coupler Force	Load Cell	+/- KIPS	Curve Stability
SP1	Lateral Coupler Disp.(1)	String Pot	+/- KIPS	Characterization
SP2	Lateral Coupler Disp.(2)	String Pot	+/- KIPS	Characterization
SP3	Longitudinal Coupler Disp.(1)	String Pot	+/- KIPS	Characterization
SP4	Longitudinal Coupler Disp.(2)	String Pot	+/- KIPS	Characterization

ATTACHMENT 2

AAR/TTC INSTRUMENTATION STANDARD OPERATING PROCEDURE NO. 024 (SEPT.,1990)

AAR/TTC INSTRUMENTATION
STANDARD OPERATING PROCEDURE NO. 024 (SEPT.,1990)

1.0 TITLE: Accelerometer selection and installation guidelines.

2.0 CANCELLATION: N/A

3.0 EXPERIMENT REFERENCE: N/A

4.0 SAFETY!!! TTC RULE BOOK.

5.0 DEFINITION/TERMINOLOGY: TTC Instrumentation will use the USA units of measurement for Dynamic Measurements and the most common symbols for the commonly excepted statistical values as listed below with other common abbreviations:

PARAMETER	SYMBOL	VALUE	DEFINITION
ACCELERATION "g" UNITS	A	0-TO-PEAK	A=0.0511f D
DISPLACEMENT	D	PEAK-TO-PEAK	INCHES DOUBLE AMPLITUDE
VELOCITY	V	0-TO-PEAK	INCHES/SECOND
PIEZOELECTRIC	PE		PYROELECTRICITY CRYSTAL TRANSDUCER
PIEZORESISTIVE	PR		SOLID STATE STRAIN TRANSDUCER

6.0 REFERENCES: The following documents should be referred to for further details. Manufactures data sheets for selected transducers (available in Instrumentation Library) and Endevco Measurement Technology Handbook P/N 29005.

7.0 SCOPE: This procedure was written to help standardize the way acceleration data is obtained at the TTC. It is to be used as a guide for measurement taken at near ambient temperatures and for vibration frequency under one (1) KiloHertz. All special requirements will be referred to the Instrumentation Engineering Staff.

8.0 TRANSDUCER SELECTION: The required accuracy, frequency and "g" range should be specified by the test plan. This information, while required, is not sufficient to select the transducer. We must also have knowledge of the physical environment the transducer will operate in. While most of our railroad requirements are limited to DC to 30 Hz data, truck mounted transducers must be able to survive high g shock inputs. For this reason we do not mount Servo accelerometers directly on trucks as it will damage the internal suspension of the force coil. The truck environment therefore requires we use 2 to 25 G Pieloresistive or capacitance type accelerometers. The table shown below list the features of several common accelerometers used at the TTC. After reviewing available transducer, the transducer user should review manufacturer's data and TTC error analysis for each type considered.

MODEL/MFG	TYPE	TYPICAL RESPONSE	USEFUL TEMP RANGE(F)	NOTES
2262 Endevco	PR	DC-650Hz	25 - 150	Stud Mount
7290 Endevco	Capacitance	DC-600Hz	-45 - 160	Cap Screw Mount
SA-101HP Columbia	Servo	DC-60Hz	-45 - 200	Bearing Suspension
141A Serta	Capacitance	DC-200Hz	-10 - 150	Screw Mount
303T Kisler	Servo	DC-600	25 - 150	Obsolete but rugged
303A02 PCZ	Quartz	.7 - 20Hz	-40 - 200	Requires ChargeAmp
LSB Schaevitz	Servo	DC-60Hz	25 - 150	Bearing Suspension

A. High acceleration shock pulses should use "PE" transducers with selected bandwidth signal conditioners see Endveco Handbook P/N 29005 Section III page 15.

B. Low level, high linearity, low frequency measurements. Servo accelerometers should be used if no high frequency or shock type inputs will exist (Do Not Use Directly Mounted To Truck/Bogie Hardware). If truck mounted data required use "PR" or capacitance type sensors.

C. Low frequency, low level measurements such as car body motion use either Servo or High Sensitivity "PR" or capacitance sensors.

D. Long duration shock pulses should be performed with "PR" accelerometers due to good DC stability and good frequency response.

E. Seismic or Static (DC) acceleration should only be done with Servo accelerometers due to superior DC stability.

F. Measurement on light or sheet metal structures should be done with low mass "PR" accelerometers.

G. Use of velocity and Displacement output sensors is not recommended. If velocity or displacement is required acceleration will be integrated or doubled-integrated.

H. For high temperature or high frequency (above 5,000 Hertz) measurements consult instrumentation engineering.

9.0 CALIBRATION: Verify valid hardware calibration and enter data on acquisition form.

10.0 INSTALLATION GUIDELINE:

A. Surface of accelerometer and test specimen must be flat, clean and smooth.

B. Use recommended mounting torque +/- 10% at all times. The TTC has the proper wrenches and sockets for all its transducers. 10-32 stud = 18 in lb, 6-32 = 10 in lb and 4-40 = 8 in lb.

C. Use machinist squares and/or levels to verify proper sensitive axis alignment. X axis is longitudinal with plus looking through car from B end. Plus lateral (Y axis) is right to left looking from B to A end. Z axis is going up from rail head.

D. When not using mounting block select accelerometer with low base strain sensitivity.

E. If installation could be sensitive to electrical noise pickup use isolated mounts with transducer case grounded and single ended signal conditioner.

F. Protect accelerometer from any external heat source. If elevated temperature operation is required a elevated temperature calibration should be performed.

G. Protect "PE" accelerometer installation from Triboelectric noise by use of noise treated cables in area of vibration and restraining then as close to transducer as possible.

H. Use dental cement for short term mounting block or cementing stud installation on irregular surfaces. Use epoxy cements such as Epon 828 or Epibond 1210 for long term installations. Never apply cement directly to any accelerometer base with threaded mounting provisions.

I. Accelerometer input cables should never be stepped on, kinked, knotted, removed or installed in such a manner as to bend connector pins. They must be securely tightened and a drip loop provided at the transducer.

J. If transducer is not specified by test plan or TTC SOP perform an error analysis per TTC SOP 023 to prove selected transducer will provide desired data accuracy.

K. Perform an end to end system check such as a roll calibration on "PR" or Servo accelerometers or tap test on "PE" transducers.

L. Document installation with sketches and/or photo's.

APPENDIX B

CHAPTER XI AAR'S M-1001 MANUAL OF STANDARDS AND RECOMMENDED PRACTICES

CHAPTER XI

SERVICE-WORTHINESS TESTS AND ANALYSES FOR NEW FREIGHT CARS

Adopted 1987

11.1. PURPOSE AND SCOPE

This chapter presents guidelines for testing and analysis to ascertain the interchange-service worthiness of freight cars. The regimes of vehicle performance to be examined are divided into two sections. Section 1 covers structural static and impact requirements. Section 2 covers vehicle dynamic performance, with the following regimes to be examined: hunting, car body twist and roll, pitch and bounce, yaw and sway and longitudinal train action.

Braking performance, structural fatigue life, car handling, and other design considerations must be considered in accordance with requirements outlined by other chapters of this specification.

The methods presented provide acceptable approaches to the analysis and measurement of car parameters and performance. Other rational methods may be proposed at the time of submission for design approval. Their use and applicability must be agreed to by the Car Construction Committee.

11.2. STATIC AND IMPACT TEST REQUIREMENTS

Application for approval of new and untried types of cars, along with supporting data specified in paragraph 1.2.3, shall be submitted to the Director—Technical Committees Freight Car Construction prior to initiation of official AAR testing. A proposed testing schedule and testing procedures will be submitted sufficiently in advance of tests to permit review and approval of the proposal and assignment of personnel to witness tests as AAR observers. Tests will be in conformity with the following and all costs are to be borne by the applicant, including observers.

11.2.1. TEST CONDITIONS

11.2.1.1.

A car of the configuration proposed for interchange service must be utilized for all tests. Deviation from such configuration is only permitted with the explicit permission of the Car Construction Committee.

During impact tests, the test car will be the striking car and shall be loaded to AAR maximum gross rail load for the number and size of axles used under car (see 2.1.5.17). Exceptions to this procedure will be considered by the Car Construction Committee when justified by the applicant.

Cars designed for bulk loading shall have a minimum of 85% of the total volume filled.

Cars designed for general service, other than bulk loading, shall be loaded so that the combined center of gravity of car and loading is as close as practicable to the center of gravity computed in accordance with the requirements of 2.1.3, except that general service flat cars may be loaded by any practicable method. The loads shall be rigidly braced where necessary, and various types of loads should be used to test each component to its maximum load.

The test car may be equipped with any AAR-approved draft gear or any AAR-approved cushioning device for which the car was designed.

11.2.1.2.

The cars, other than the test car, shall be of seventy ton nominal capacity, loaded to the allowable gross weight on rails prescribed in 2.1.5.17. A high density granular material should be used to load cars to provide a low center of gravity, and the load should be well braced to prevent shifting. Such cars shall be equipped with draft gears meeting the requirements of AAR Specification M-901, except at the struck end where M-901E rubber friction gear shall be used.

Free slack between cars is to be removed, draft gears are not to be compressed. No restraint other than handbrake on the last car is to be used.

11.2.2. INSTRUMENTATION

The coupler force shall be measured by means of a transducer complying with AAR Specification M-901F, or other approved means. Instrumentation used for recording of other data shall be generally acceptable type properly calibrated and certified as to accuracy.

Speed at impact shall be recorded.

11.2.3. STATIC TESTS

11.2.3.1. COMPRESSIVE END LOAD

A horizontal compressive static load of 1,000,000 lbs, shall be applied at the centerline of draft to the draft system of car/unit structure interface areas, and sustained for a minimum 60 seconds. The car/unit structure tested shall simulate an axially loaded beam having rotation free-translation fixed end restraints. (See Figure 11.2.3.1).

No other restraints, except those provided by the suspension system in its normal running condition, are permissible. Multi-unit car must have each structurally different unit subjected to such test, also two empty units joined together by their connector shall undergo this test to verify the connectors compressive adequacy and its anti-jackknifing properties.

The test is to be performed with the car subjected to the most adverse stress or stability conditions (empty and/or loaded).

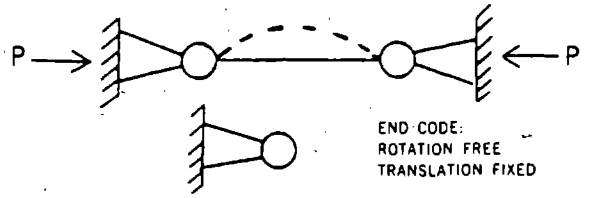

Figure 11.2.3.1

11.2.3.2. COUPLER VERTICAL LOADS

A vertical upward load shall be applied to the coupler shank immediately adjacent to the striker face or to the face of the cushion unit body at one end of the car, sufficient in magnitude to lift the fully loaded car free of the truck nearest the applied load, and held for sixty seconds. Cushion underframe cars having sliding sill are excluded from the requirements of this paragraph.

For cushion underframe cars having sliding sills, a vertical upward load shall be applied to the sliding sill in a plane as near the ends of the fixed center sills as practicable, sufficient in magnitude to lift the fully loaded car free of the truck nearest the applied load, and held for sixty seconds.

For all cars, a load of 50,000 pounds shall be applied in both directions to the coupler head as near to the pulling face as practicable and held for sixty seconds.

11.2.3.3. CURVE STABILITY

The test consist is to undergo a squeeze and draft load of 200,000 lbs. without car body-suspension separation or wheel lift. Load application shall simulate a static load condition and shall be of minimum 20 seconds sustained duration.

Cars consisting of more than two units shall be tested with a minimum of three units in the test consist. The number of units used shall generate maximum load in the critical L/V location of the car.

For the purpose of this test, wheel lift is defined as a separation of wheel and rail exceeding ⅛" when measured 2⅝" from the rim face at the inside of curve for buff and outside for draft.

Empty car shall be subjected to squeeze and draft load on a curve of not less than 10 degrees. The curve is to have ½" maximum superelevation. The test car is to be coupled to a "base car" as defined in paragraph 2.1.6.1. or a like car which ever is most severe and a "long car" having 90' over strikers, 66' truck centers, 60" couplers and conventional draft gear.

The test consist shall have means for measuring and recording coupler forces.

11.2.3.4. RETARDER AND "HOT BOX" DETECTION

Cars with other than conventional 3 piece trucks must be operated while fully-loaded over a hump and through a retarder. Retarder shall be operated to determine capability to brake the test cars. Such cars must also demonstrate their compatibility with hot box detection systems or be equipped with on-board hot box detection systems.

11.2.3.5. JACKING

Vertical load capable of lifting a fully loaded car/unit shall be applied at designated jacking locations sufficient to lift the unit and permit removal of truck or suspension arrangement nearest to the load application points.

11.2.3.6. TWIST LOAD

Loaded car/unit shall be supported on the side bearings or equivalent load points only. Diagonally opposite bearing or load point support shall be lowered through a distance resulting from a calculated 3" downward movement of one wheel of the truck or suspension system supporting it. No permanent deformation of car/unit structure shall be produced by this test.

11.2.4. IMPACT TESTS

These requirements apply to all cars except those exempted by other specification requirements.

11.2.4.1. SINGLE CAR IMPACT

The loaded car shall be impacted into a string of standing cars consisting of three nominal 70-ton capacity cars, loaded to maximum gross weight on rails as described in paragraph 2.1.5.17. with sand or other granular material, equipped with M-901E rubber-friction draft gear at the struck end and with the hand brake on the last car on the non-struck end of the string tightly set. Free slack between cars is to be removed; however, draft gears are not to be compressed. No restraint other than handbrake on the last car is to be used.

A series of impacts shall be made on tangent track by the striking car at increments of two miles per hour starting at six miles per hour until a coupler force of 1,250,000 pounds or a speed of fourteen miles per hour has been reached, whichever occurs first.

A car consisting of two or more units must also undergo impact testing as outlined above with the leading unit of the test car being empty for a two-unit car, or with the first two units being empty for a three (or more) unit car. No carbody-suspension disengagement or wheel lift is permitted during the partially loaded impact tests.

11.2.4.2. DYNAMIC SQUEEZE

(Optional–May be performed in lieu of or in addition to static end compression test if requested by the Car Construction Committee.)

The striking and standing car groups shall each consist of six cars, in which the test car may be the lead car in either group. All cars except the test car shall be as prescribed in 11.2.1.2. The brakes shall be set on all standing cars after all slack between cars has been eliminated. There shall be no precompression of the draft gears. The standing cars shall be on level tangent track. The striking cars, coupled together, shall be adjusted, if necessary, to restore the original conditions.

A series of impacts shall be made at increments of two miles per hour starting at six miles per hour until a coupler force of 1,250,000 pounds or a speed of fourteen miles per hour has been reached, whichever occurs first.

11.2.5. INSPECTION

A visual inspection of the test car shall be made after each static test and after each impact. Following the impact tests, the car shall be unloaded and inspected.

Any permanent damage to any major structural part of the car, found before or after all tests are completed, will be sufficient cause for disapproval of the design. Damage will be considered permanent when the car requires shopping for repairs.

11.3. TRACK-WORTHINESS ASSESSMENT

11.3.1. METHODOLOGY

Regimes are identified, representative of the performance of the car in service. Tests are defined for each regime. The results of the tests are an indication of the car's track-worthiness. In most regimes, analytic methods are also available to permit prediction to be made of the performance of the car, to the degree of accuracy required.

The characteristic properties of the car body and its suspension, required for the analysis, shall be supported by evidence of their validity. Characterization tests, such as those defined in Appendix A, are required to verify the values used in the analyses.

11.3.2. TRACK-WORTHINESS CRITERIA

The criteria applied to the analyses and tests are chosen from a consideration of the processes by which cars deviate from normal and required guidance. They are also subject to the requirement of observability in tests. Typical of these are lateral and vertical forces, the lateral over vertical force (L/V) ratios, dynamic displacements, and accelerations of the masses. These criteria are based on considerations of the processes of wheel climb, rail and track shift, wheel lift, coupler and component separation and structural integrity.

The values chosen for the criteria selected have been used in tests on cars presently in service. Those included in the body of this chapter are shown in Table 11.1. Values worse than these are regarded as having a high risk of unsafe behavior. Values better than these are regarded as indicating the likelihood of safe car performance.

Table 11.1 Criteria for Assessing the Requirements for Field Service

Regime	Section	Criterion	Limiting Value
Hunting (empty)	11.5.2	minimum critical speed (mph)	70
		maximum lateral acceleration (g)	1.0
		maximum sum L/V axle	1.3*
Constant curving (empty and loaded)	11.5.3	95th percentile maximum wheel L/V	0.8
		or	
		95th percentile maximum sum L/V axle	1.3
Spiral (empty and loaded)	11.5.4	minimum vertical load (%)	10 **
		maximum wheel L/V	0.8*
Twist, Roll (empty and loaded)	11.6.2	maximum roll (deg)***	6
		maximum sum L/V axle	1.3
		minimum vertical load (%)	10 **
Pitch, Bounce (loaded)	11.6.3	minimum vertical load (%)	10 **
Yaw, Sway (loaded)	11.6.4	maximum L/V truck side	0.6*
		maximum sum L/V axle	1.3*
Dynamic curving (loaded)	11.6.5	maximum wheel L/V	0.8*
		or	
		maximum sum L/V axle	1.3*
		maximum roll (deg) **	6
		minimum vertical load (%)	10 **
Vertical curve	11.7.2	to be added****	
Horizontal curve	11.7.3	to be added****	

* Not to exceed indicated value for a period greater than 50 milliseconds per exceedence

** Not to fall below indicated value for a period greater than 50 milliseconds per exceedence

*** Peak-to-peak

**** See the introduction to section 11.7.1

11.4. GLOSSARY OF TERMS

Radial misalignment of axles in a truck or car is the difference in yaw angle in their loaded but otherwise unforced condition. It causes a preference to curving in a given direction.

Lateral misalignment is the difference in lateral position between axles. It causes both axles to be yawed in the same direction on straight track.

Inter-axle shear stiffness, equivalent to the lozenge or tramming stiffness in 3-piece trucks, is the stiffness between axles in a truck or car found by shearing the axles in opposite directions along their axes, and measuring the lateral deflection between them.

Inter-axle bending stiffness is the stiffness in yaw between axles in a truck or car.

Bounce is the simple vertical oscillation of the body on its suspensions in which the car body remains horizontal.

Pitch of the body is the rotation about its transverse axis through the mass center.

Body yaw is the rotation of the body about a vertical axis through the mass center.

Body roll is the rotation about a longitudinal axis through the mass center.

Upper and lower center roll are the coupled lateral motion and roll of the body center of mass. They combine to give an instantaneous center of rotation above or below the center of mass. When below the center of mass, the motion is called lower center roll. When above, the motion is called upper center roll.

Sway is the coupled body mode in roll and yaw and it occurs where the loading is not symmetrical.

Unbalance is used in this chapter to mean the additional height in inches, which if added to the outer rail in a curve, at the designated car speed, would provide a single resultant force, due to the combined effects of weight and centrifugal force on the car, having a direction perpendicular to the plane of the track. Thus, the unbalance (U) is defined as:

$$\text{Unbalance } U = \frac{V^2 D}{1480} - H$$

where,
D is the degree of the curve.
V is the vehicle speed in mph.
H is the height, in inches, of the outer rail over the inner rail in the curve.

Effective conicity, E, of a wheel on a rail is its apparent cone angle used in the calculation of the path of the wheel on the rail. It is defined as:

$$E = A\left(\frac{R_w}{R_w - R_R}\right)$$

where,
A is the angle of the contact plane between the wheel and rail, to the plane of the track.
R_w is the transverse profile radius of the wheel.
R_R is the transverse profile radius of the rail.

The effective conicity of the modified Heumann wheel of Figure 8.1 on AREA 132 lb rail, under conditions of tight gage, is between 0.1 and 0.3.

120

Three ratios of lateral (L) to vertical (V) forces are used as criteria in the assessment of car performance. These are:

(1) **The individual wheel L/V**, (or wheel L/V). This is defined as the ratio of the lateral force to the vertical force between the wheel and rail on any individual wheel. It is used to assess the proximity of the wheel to climbing the rail.

(2) **The instantaneous sum of the absolute wheel L/V's on an axle**, (or sum L/V axle). This is defined as the sum of the absolute values of the individual wheel L/V's on the same axle, as given in the following algebraic equation. They must be measured at the same time.

$$\text{Sum L/V axle} = \left| \text{L/V (left whl)} \right| + \left| \text{L/V (right whl)} \right|$$

It is used to assess the proximity of the wheel to climbing the rail and is more appropriate where the angle of attack of the flanging wheel to the rail does not result in full slippage at the area of contact.

(3) **The truck side L/V**, (or L/V truck side). This is defined as the total sum of the lateral forces between the wheels and rails on one side of a truck divided by the total sum of the vertical forces on the same wheels of the truck, as given in the following algebraic expression.

$$\text{Truck side L/V} = \frac{\Sigma\text{L (truck side)}}{\Sigma\text{V (truck side)}}$$

It is used to indicate the proximity to moving the rail laterally.

11.5. SINGLE CAR ON UNPERTURBED TRACK

11.5.1. GENERAL

The regimes described in this section are chosen to test the track-worthiness of the car running on premium track. They are required to establish the safety of the car from derailment under conditions basic to its performance in service and are carried out under operating conditions similar to those found in normal service, but without the effects of dynamic variations due to adjacent cars or large perturbations associated with poor track.

The parameters used in the analysis shall be confirmed in characterization tests described in Appendix A. The results of the following analyses and tests shall be included for the consideration of approval by the Car Construction Committee.

11.5.2. LATERAL STABILITY ON TANGENT TRACK (HUNTING)

This requirement is designed to ensure the absence of hunting, which can result from the transfer of energy from forward motion into a sustained lateral oscillation of the axle between the wheel flanges, in certain car and suspension designs. The analyses and tests are required to show that the resulting forces between the wheel and rail remain within the bounds necessary to provide an adequate margin of safety from any tendency to derail.

11.5.2.1. PREDICTIONS AND ANALYSES

An analysis shall be made of the critical speed at which continuous full flange contact is predicted to commence, using a validated mathematical model and the parameters measured for the empty test car. This analysis shall include predictions on tangent and on 1/2 and 1 degree curves.

The analytic requirement is that no hunting be predicted for the empty car below 70 miles per hour assuming a coefficient of friction of 0.5 and an effective conicity of 0.15, for the modified Heumann wheel profile given in Figure 8.1 of Chapter VIII, on new AREA 136 lb. rail, for axle lateral displacements up to +/− 0.2 in. on track with standard gauge.

11.5.2.2. TEST PROCEDURE AND CONDITIONS

The empty test car shall be placed at the end of the test consist, behind a stable buffer car, and operated at speeds up to 70 miles per hour on tangent class 5 or better track, with dry rail.

All axles of the lead unit or car shall be equipped with modified Heumann profile wheels as shown in Figure 8.1 of Chapter VIII, with the machining grooves worn smooth on the tread.

The rail profile shall be new AREA 136 lb. or an equivalent which, with the Heumann wheel specified, gives an effective conicity of at least 0.15 for lateral axle displacements of +/− 0.2 inch from the track center. The track gage may be adjusted in order to achieve this minimum effective conicity. If hunting is predicted for curved track in section 11.5.2.1, a special hunting test in shallow curves may be requested.

11.5.2.3. INSTRUMENTATION AND CRITERIA

The leading axle of both trucks on an end unit or car, or each axle on an end unit or car with single-axle trucks, shall be equipped with instrumented wheelsets, and each truck location on the end unit or car shall be equipped with a lateral accelerometer on the deck above the center of the truck.

Sustained truck hunting shall be defined as a sustained lateral acceleration greater than 1 g peak-to-peak for at least 20 consecutive seconds. No occurrences of greater than 1.5 g peak-to-peak are permitted within the same time period. The instantaneous sum of the absolute values of the L/V ratios shall not exceed 1.3 on any instrumented axle. Components of the measured accelerations and forces having frequencies above 15 hertz are to be filtered out.

The car shall not experience sustained truck hunting during the test. A record of maximum lateral acceleration and the wheel L/V's on the same axle, against speed, at the worst location, shall be submitted as required test data.

11.5.3. OPERATION IN CONSTANT CURVES

This requirement is designed to ensure the satisfactory negotiation of track curves. The analyses and tests are required to show that the resulting forces between the wheel and rail are safe from any tendency to derail and to confirm other predictions of the car behavior relating to the guidance of the car and absence of interferences.

11.5.3.1. PREDICTIONS AND ANALYSES

An analysis shall be made of the wheel forces and axle lateral displacements and yaw angles on a single car, empty and fully loaded, using a validated mathematical model. The model shall include a fundamental representation of the rolling contact forces using the geometry of the profiles of the wheel and rail, and car parameters from the measurements described in Appendix A.

Either the individual wheel L/V shall be less than 0.8 on all wheels measured, or the instantaneous sum of the absolute wheel L/Vs on any axle shall be less than 1.3, for any curve up to 15 degrees. The range of unbalance assumed shall be −3 inches to +3 inches, with a coefficient of friction of 0.5 and modified Heumann profiled wheels on new AREA 132 lb. or 136 lb. rail.

11.5.3.2. TEST PROCEDURE AND CONDITIONS

The test car shall be operated at constant speeds equivalent to unbalances of −3, 0, and +3 inches. The tests shall be run with the test car in both empty and fully loaded conditions, between two heavy buffer cars, one of which may be replaced by an instrumentation car. A complete set of tests shall be carried out in both directions and with the test consist turned in each direction, on dry rail.

The wheels of the test car shall have less than 5000 miles wear on the new profiles specified for production, except that those on instrumented wheelsets shall have modified Heumann profiles. The rail profiles shall have a width at the top of the head not less than 95 percent of the original value when new. The test curve shall be of not less than 7 degrees with a balance speed of 20 to 30 mph, and with class 5 or better track.

11.5.3.3. INSTRUMENTATION AND CRITERIA

The leading axle of both trucks on an end unit or car, or each axle on an end unit or car with single-axle trucks, shall be equipped with instrumented wheelsets. The lateral and vertical forces and their ratio, L/V, shall be measured for the length of the body of the curve, which must be at least 500 ft., and their maxima and means computed. Measured force components having frequencies above 15 hertz are to be filtered out.

Either the individual wheel L/V shall be less than 0.8 on all wheels measured, or the instantaneous sum of the absolute wheel L/Vs on any axle shall be less than 1.3. A record of L/V on both wheels of the instrumented axles, for each test run, shall be submitted as required test data.

11.5.4. SPIRAL NEGOTIATION AND WHEEL UNLOADING

This requirement is designed to ensure the satisfactory negotiation of spirals leading into and away from curves. The analyses and tests are required to show that the resulting forces between the wheel and rail show an adequate margin of safety from any tendency to derail, especially under reduced wheel loading, and to confirm other predictions of the car behavior.

11.5.4.1. PREDICTIONS AND ANALYSES

An analysis shall be carried out of the lateral and vertical wheel forces on a single car, with the car loaded asymmetrically, consistent with AAR loading rules, to give maximum wheel unloading.

The analysis shall be made for a speed equivalent to a mean unbalance at the car center of −3 inches to +3 inches with a coefficient of friction of 0.5 and modified Heumann wheel and new AREA 132 lb. or 136 lb. rail profiles.

The predicted lateral-to-vertical force ratio shall not exceed 0.8, and no vertical wheel load shall be less than 10 percent of its static value, in a bunched spiral, with a change in superelevation of 1 inch in every 20 ft, leading into a curve of at least 7 degrees and a minimum of 3 inches superelevation.

11.5.4.2. TEST PROCEDURE AND CONDITIONS

This test may be carried out concurrently with the previous test, paragraph 11.5.3.2. The test car shall be operated, empty and fully loaded, between two heavy buffer cars, one of which may be an instrumentation car, at constant speeds equivalent to an unbalance of −3, 0, and +3 inches at the maximum curvature.

The wheels of the test car shall have less than 5000 miles wear on the new profiles specified for production, except that those on instrumented wheelsets shall have modified Heumann profiles. The rail profiles shall have a width at the top of the head not less than 95 percent of the original value when new.

The maximum curvature shall be not less than 7 degrees, with a minimum of 3 inches superelevation. A bunched spiral, with a change in superelevation of not less than 1 inch in every 20 ft., is required. The track shall be class 5 or better and dry. Tests shall be run in both directions and with the consist turned.

11.5.4.3. INSTRUMENTATION AND CRITERIA

The leading axle on both trucks on an end unit or car, or each axle on an end unit or car with single-axle trucks, shall be equipped with instrumented wheelsets.

The lateral and vertical forces and their ratio, L/V, shall be measured continuously through the bunched spiral, in both directions, and their maxima and minima computed. Measured force components having frequencies above 15 hertz are to be filtered out.

The maximum L/V ratio on any wheel shall not exceed 0.8, and the vertical wheel load shall not be less than 10 percent of the measured static value. A record of L/V's and vertical forces on both wheels of the two worst axles in a car, and car body roll angle, for each test, shall be submitted as required test data.

11.6. SINGLE CAR ON PERTURBED TRACK

11.6.1. GENERAL

The analyses and tests described in this section are designed to establish the trackworthiness of the car under conditions associated with variations in the track geometry. They include the dynamic response due to perturbations in the track but exclude the dynamic effects due to coupling with adjacent cars.

The investigations are designed to demonstrate that the car design provides an adequate margin of safety from structural damage and from any tendency to derail.

The tests shall be completed and their results found satisfactory by the AAR observers. The results identified shall be added as required data for the consideration of the Car Construction Committee.

11.6.2. RESPONSE TO VARYING CROSS-LEVEL (TWIST AND ROLL)

This requirement is designed to ensure the satisfactory negotiation of oscillatory cross-level excitation of cars, such as occurs on staggered jointed rail, which may lead to large car roll and twist amplitudes. The analyses and tests are required to show that the resulting forces between the wheel and rail show an adequate margin of safety from any tendency to derail.

11.6.2.1. PREDICTIONS AND ANALYSES

A review shall be made of any tests and analyses for the natural frequency and damping of the car body, in the roll and twist modes, in the empty and fully loaded conditions, and an estimate made of the speed of the car at each resonance.

The maximum amplitude of the carbody in roll and twist, the maximum instantaneous sum of the absolute values of the wheel L/V ratios on any axle, the minimum vertical wheel load, and the number of cycles to reach them, shall be predicted at resonant speed of 70 mph or below, on tangent track, with staggered jointed rails of 39 ft. length, and a maximum cross-level at the joints of 0.75 in. as shown in Fig. 11.1.

The instantaneous sum of the absolute values of the wheel L/V ratios on any axle shall be less than 1.3, the predicted roll angle of the carbody shall not exceed 6 degrees peak-to-peak, and the vertical wheel load shall not be less than 10 percent of its static value, within 10 rail lengths of the start, at any speed at or below 70 mph.

11.6.2.2. TEST PROCEDURE AND CONDITIONS

The test car shall be between two cars chosen for their stable performance. Tests shall be carried out with the test car empty and fully loaded.

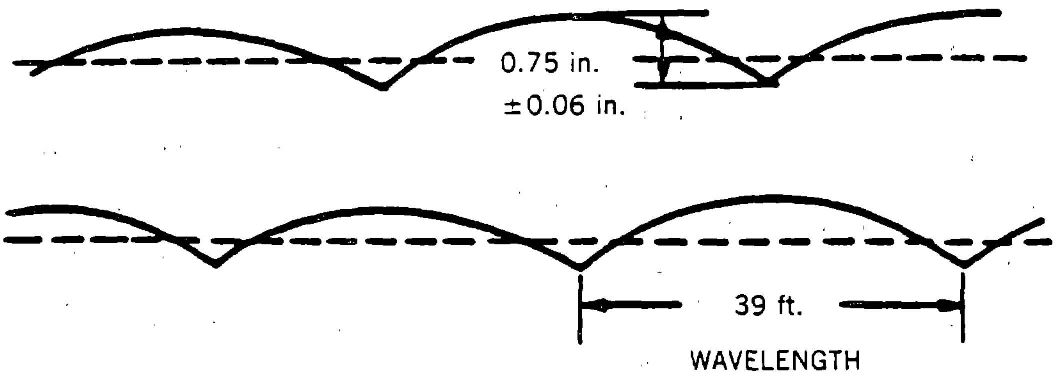

Figure 11.1.

TRACK CROSS LEVEL FOR THE TWIST AND ROLL TEST

The test shall be on tangent track with staggered 39 ft. rails on good ties and ballast, shimmed to a cross level of 0.75 in., low at each joint as shown in Fig. 11.1, over a test zone length of 400 ft., but otherwise held to class 5 or better.

The test shall be carried out at constant speed, increasing in 2 mph steps from well below any predicted resonance until it is passed, or approaching it from a speed above that expected to give a resonant condition. The test shall be stopped if an unsafe condition is encountered or if the maximum of 70 mph is reached. It shall be regarded as unsafe if a wheel lifts or if the car body roll angle exceeds 6 degrees, peak-to-peak.

11.6.2.3. INSTRUMENTATION AND CRITERIA

The leading axle of both trucks on an end unit or car, or each axle on an end unit or car with single-axle trucks, shall be equipped with instrumented wheelsets. The car body roll angle shall also be measured at a minimum of each end of an end unit.

The wheel forces, the mean roll angle and difference in roll between ends for each unit, shall be measured continuously through the test zone. Measured force components having frequencies above 15 hertz are to be filtered out.

The sum of the absolute values of wheel L/V on any instrumented axle shall not exceed 1.3, the roll angle of the carbody of any unit shall not exceed 6 degrees peak-to-peak and the vertical wheel load shall not be less than 10 percent of its static value at any speed tested.

A record of the vertical loads measured at the axle with the lowest measured vertical load, and the roll angles measured at each end of the most active unit of the car, taken at the resonant speeds for each car load, shall be submitted as required test data.

11.6.3. RESPONSE TO SURFACE VARIATION (PITCH AND BOUNCE)

This requirement is designed to ensure the satisfactory negotiation of the car over track which provides a continuous or transient excitation in pitch and bounce, and in particular the negotiation of grade crossings and bridges, where changes in vertical track stiffness may lead to sudden changes in the loaded track profile beyond those measured during inspection. The analyses and tests are required to show that the resulting forces between the wheel and rail show an adequate margin of safety from any tendency for the car to derail, to uncouple, or to show interference either between subsystems of the car or between the car components and track.

11.6.3.1. PREDICTIONS AND ANALYSES

A review shall be made of any tests and analyses for the natural frequency and damping of the car body, fully loaded, in the modes of pitch and bounce, and an estimate made of the resonant speed of the car when excited by a track wavelength of 39 feet.

The vertical wheel load shall be predicted at these speeds or at 70 mph, whichever is greater, for a continuous near sinusoidal excitation with a vertical amplitude to the track surface of 0.75 inches peak-to-peak and a single symmetric vertical bump in both rails, of the shape and amplitude shown in Fig. 11.2, predicted vertical wheel load shall not be less than 10 percent of its static value at any resonant speed at or below 70 mph, within 10 rail lengths of the start of the continuous sinusoid or following the single bump.

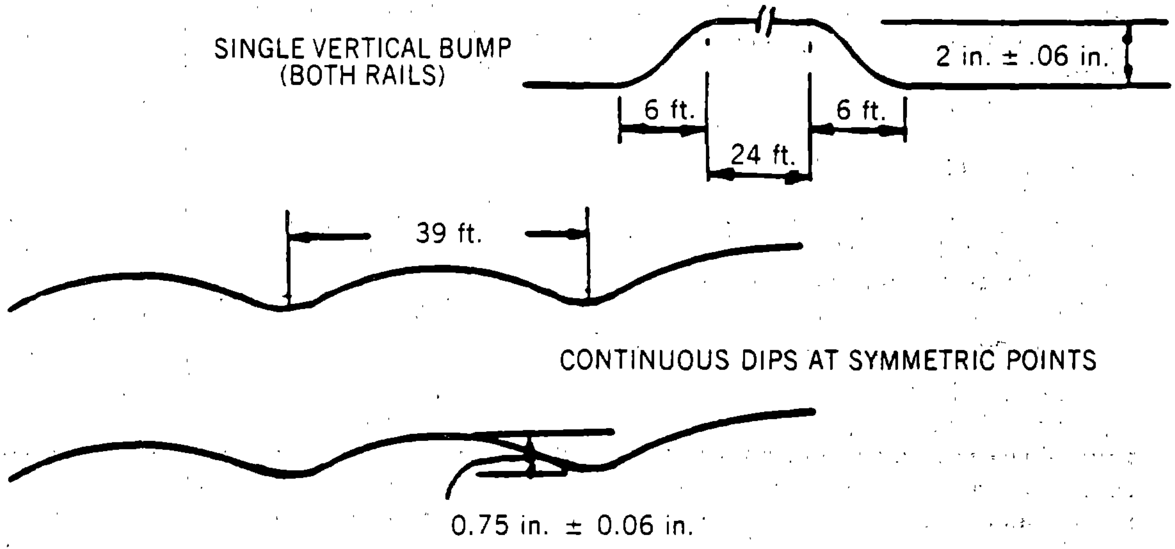

Figure 11.2.

TRACK SURFACE VARIATION FOR PITCH AND BOUNCE

11.6.3.2. TEST PROCEDURE AND CONDITIONS

The fully loaded test car shall be tested between two light cars that have at least 45 ft. truck center spacing.

Tests shall be carried out on tangent track with surface deviations providing a continuous, near sinusoidal, excitation with a vertical amplitude to the track surface of 0.75 inches peak-to-peak and a single symmetric vertical bump in both rails of the shape and amplitude shown in Fig. 11.2. These tests may be carried out separately, or together, with a separation of at least 100 feet. The track shall otherwise be held to class 5 or better.

Testing shall start at constant speed well below any predicted resonant speed, increasing in 5 mph steps until an unsafe condition is encountered, the resonance is passed, or the maximum of 70 mph is reached. The speed at which resonance is expected may be approached from a higher speed, using steps to decrease the speed. It shall be regarded as unsafe if any wheel lifts.

11.6.3.3. INSTRUMENTATION AND CRITERIA

The leading axle on both trucks on an end unit or car, or each axle on an end unit or car with single-axle trucks, shall be equipped with instrumented wheelsets. The vertical wheel forces shall be measured continuously through the test zone. Measured force components having frequencies above 15 hertz are to be filtered out.

The vertical wheel load shall not be less than 10 percent of its static value on any wheel at any speed tested. A record of the vertical loads measured on the axle with the lowest vertical load shall be submitted as required test data.

11.6.4. RESPONSE TO ALIGNMENT VARIATION ON TANGENT TRACK (YAW AND SWAY)

This requirement is designed to ensure the satisfactory negotiation of the car over track with misalignments which provide excitation in yaw and sway. The analyses and tests are required to show that the resulting forces between the wheel and rail show an adequate margin of safety from any tendency for the car forces to move the track or rail or to give interference either between subsystems of the car or between the car components and track.

11.6.4.1. PREDICTIONS AND ANALYSES

A review shall be made of the previous tests and analyses for the natural frequency and damping of the car body, fully loaded, in the yaw and roll modes. These may combine in a natural motion referred to as sway, which, if present, must be included in this analysis. Using the values for frequency and damping identified, an estimate shall be made of the resonant speed of the car, in each mode.

The car shall be assumed to be excited by a symmetric, sinusoidal track alignment deviation of wavelength 39 feet, on tangent track. The ratio of the sum of the lateral to that of the vertical forces on all wheels on one side of any truck shall be predicted at resonance or at 70 mph, whichever is greater, for a sinusoidal double amplitude of 1.25 inches peak-to-peak on both rails and a constant wide gage of 57.5 inches, as shown in Fig. 11.3.

The predicted truck side L/V shall not exceed 0.6, and the sum of the absolute values of L/V on any axle shall not exceed 1.3, at any speed at or below 70 mph, within 5 rail wavelengths of the start.

11.6.4.2. TEST PROCEDURE AND CONDITIONS

The fully loaded test car shall be placed at the end of the test consist, behind a buffer car of at least 45 feet truck center spacing, chosen for its stable performance.

Tests shall be carried out on dry tangent track, with symmetric, sinusoidal alignment deviations of wave length 39 feet, alignment amplitude 1.25 inches peak-to-peak and a constant wide gage of 57.5 inches, over a test zone of 200 feet as shown in Fig. 11.3. The track shall otherwise be held to class 5 or better.

The wheels of the test car shall have less than 5000 miles wear on the new profiles specified for production, except that those on instrumented wheelsets shall have modified Heumann profiles. The rail profiles shall have a width at the top of the head not less than 95 percent of the original value when new.

127

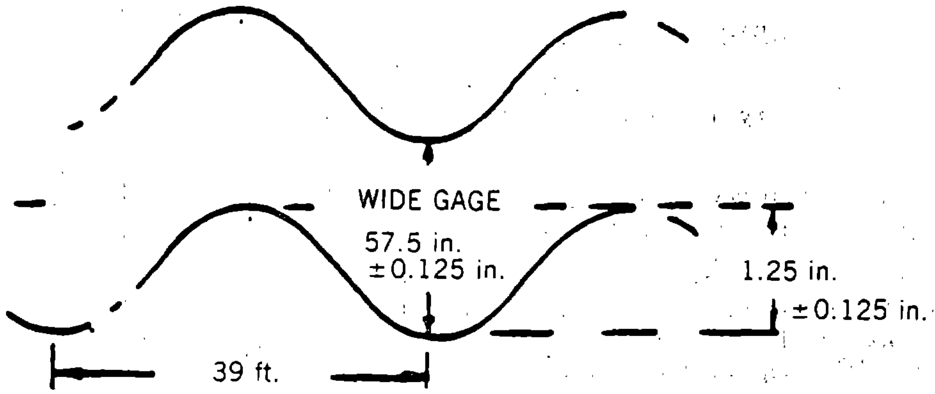

Figure 11.3.

TRACK ALIGNMENT VARIATIONS FOR YAW AND SWAY

Testing shall start at constant speed well below any predicted resonant speed, increasing in 5 mph steps until an unsafe condition is encountered, the resonance is passed, or the maximum of 70 mph is reached. It shall be regarded as unsafe if the ratio of total lateral to vertical forces, on any truck side measured, exceeds 0.6 for a duration equivalent to 6 feet of track.

11.6.4.3. INSTRUMENTATION AND CRITERIA

All axles on the truck estimated to provide the worst total truck side L/V, or each axle on an end unit or car with single-axle trucks, shall be equipped with instrumented wheelsets. The wheel forces shall be measured continuously through the test zone. Measured force components having frequencies above 15 hertz are to be filtered out.

The truck side L/V measured shall not exceed 0.6 for a duration equivalent to 6 feet of track, and the sum of the absolute values of L/V on any axle shall not exceed 1.3, at any speed at or below 70 mph. A record of the lateral and vertical loads, measured on the truck with the largest truck side L/V, shall be submitted as required test data.

11.6.5. ALIGNMENT, GAGE AND CROSS-LEVEL VARIATION IN CURVES (DYNAMIC CURVING)

This requirement is designed to ensure the satisfactory negotiation of the car over jointed track with a combination of misalignments at the outer rail joints and crosslevel due to low joints on staggered rails at low speed. The analyses and tests are required to show that the resulting forces between the wheel and rail show an adequate margin of safety from any tendency for the car forces to cause the wheel to climb the rail or to move the track or rail or to give unwanted interference, either between subsystems of the car, or between the car components and track.

11.6.5.1. PREDICTIONS AND ANALYSES

A review shall be made of the previous tests and analyses for the natural frequencies and response of the car body, fully loaded, in the yaw and roll modes.

No analysis is presently available, which can predict the results accurately for this test, for all possible designs. It is therefore necessary to provide additional safety features in the running of the test program to prevent unexpected derailments or unnecessary damage.*

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*Analyses suitable for predictions of new car performance in this test are under development and will be added later.

11.6.5.2. TEST PROCEDURE AND CONDITIONS

The test car shall be operated between two cars that are loaded to provide them with a low center of gravity. If suitable, an instrumentation car may be used as one of these cars.

Tests shall be carried out on dry rail, in a curve of between 10 and 15 degrees with a balance speed of between 15 and 25 mph, with the test car empty and fully loaded.

The wheels of the test car shall have less than 5000 miles wear on the new profiles specified for production, except that those on instrumented wheelsets shall have modified Heumann profiles. The rail profiles shall have a width at the top of the head not less than 95 percent of the original value when new.

The track shall consist of staggered rails, 39 feet long, on good ties and ballast, shimmed to provide a cross level of 0.5 inch, low at each joint, over the test zone length of 200 feet, as shown in Figure 11.4.

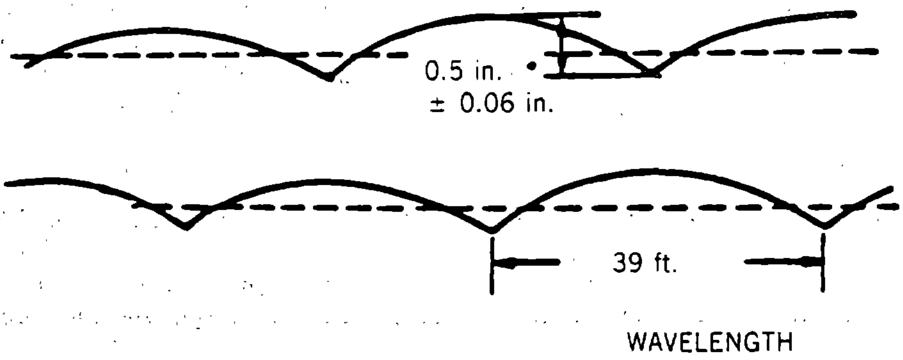

Figure 11.4.
CROSS LEVEL FOR DYNAMIC CURVING TESTS

Combined gage and alignment variation shall be provided in the test zone by shimming the outer rail in the form of an outward cusp, giving a maximum gage of 57.5 inches at each outer rail joint and a minimum gage of 56.5 inches at each inner rail joint, the inner rail being within class 5 standards for alignment in curves, as given in Figure 11.5.

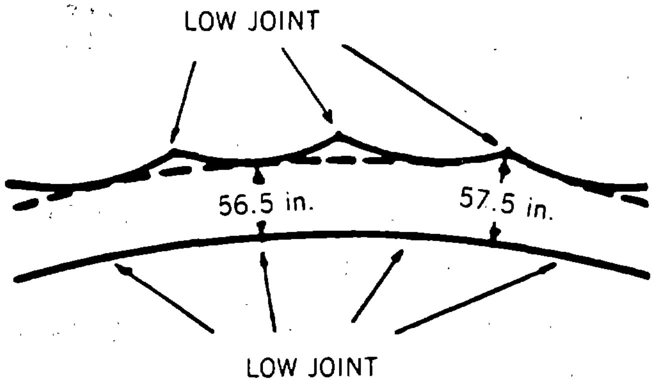

Figure 11.5.
GAGE AND ALIGNMENT VARIATION IN DYNAMIC CURVING

It is recommended that a guard rail be used to prevent unpredicted derailment; however, it must not be in contact with the wheel during normal test running. The test shall be carried out at constant speeds up to 3 inches of overbalance, increasing in 2 mph steps from well below any predicted lower center roll resonance until it is passed. The resonance may be approached from a speed above that predicted to give a lower center roll resonance.

The test shall be stopped if an unsafe condition is encountered or if the maximum unbalance is reached. It shall be regarded as unsafe if a wheel lifts, the instantaneous sum of the absolute L/V values of the individual wheels on any axle exceeds 1.3, or car body roll exceeds 6 degrees, peak-to-peak.

11.6.5.3. INSTRUMENTATION AND CRITERIA

The leading axle on both trucks on an end unit or car, or each axle on an end unit or car with single-axle trucks, shall be equipped with instrumented wheelsets. The car body roll angle shall also be measured at one end of the lead unit. The lateral and vertical wheel forces and the roll angle shall be measured continuously through the test zone. Measured force components having frequencies above 15 hertz are to be filtered out.

The maximum roll angle shall not exceed 6 degrees, peak-to-peak, the vertical wheel load shall not be less than 10 percent of its static value, the individual wheel L/V shall be less than 0.8, and the instantaneous sum of the absolute wheel L/Vs on any axle shall be less than 1.3, at any test speed.

A record of both wheel loads measured on the axle with the lowest measured vertical load and largest measured lateral load, and the roll angles measured, taken at the resonant speeds for each car load, shall be submitted as required test data.

11.7. COUPLED CARS AND UNITS

11.7.1. GENERAL

The tests described in this section will be designed to establish the track-worthiness of the car under conditions associated with the realistic operation of cars within a train. This may include severe transient forces due to coupling with adjacent cars. These forces may have a significant effect on the stability of cars and may lead to derailment. The investigations will be designed to demonstrate that the car design provides an adequate margin of safety from structural damage and from any tendency to derail.

11.7.2. VERTICALLY CURVED TRACK *

* This section to be added at a later date

11.7.3. HORIZONTALLY CURVED TRACK +

+ Investigations are currently underway which will allow the addition of this section in the near future.

APPENDIX A
VEHICLE CHARACTERIZATION
Adopted 1987

1.0. GENERAL

The characteristic properties of the car body and its suspension, required for analysis of its track-worthiness, must be supported by test results providing evidence of their validity. Forces and motions between suspension components and the body modal frequencies of the car, as assembled, can vary significantly from the values calculated or specified in the design, and may be important to the safe performance of the vehicle.

1.1. TEST CAR

It is important that characterizations be carried out on the particular car in the same condition that it is to be track tested so that accurate predictions of its performance can be made. For cars with more than one type of suspension, at least one of each type should be tested.

The tests apply to all new car suspensions, including trucks retrofitted with devices such as inter-axle connections, sideframe cross-bracing and additional suspension elements, which have not been tested previously.

Tests for horizontal characteristics of the suspension of trucks with at least two axles, may be carried out with the truck separated from the body. In this case static vertical loads must be applied to simulate those due to the body or bodies and the rotational and lateral characteristics between the truck and body must be measured separately.

Where connections exist between the truck and body that may affect the truck characteristics, such as with a truck steered through links to the body, and for all cars with single axle trucks, the suspension characteristics must be tested while connected to the body.

Where the truck is at the junction of two articulated bodies, both must be simulated or used in the suspension characterization tests specified.

1.2. TEST LOADS

Modal tests, and tests for the horizontal and vertical suspension characteristics are required with vertical loads equivalent to the car in the loaded condition required for the analyses in which the results will be used. This includes tests to measure the alignment of the axles to each other and to other elements in the system.

1.3. GENERAL PROCEDURE

In tests for the suspension characteristics, the recommended procedure is to load the suspension and to measure the load and displacement, or velocity, across the particular suspension element, in the required direction. These should be recorded up to the required maximum and down to the required minimum identified.

The loads may be applied, either through automatic cycling at an appropriate frequency or through manual increase and decrease of load through at least two complete cycles. If manual loading is used, delays and intermediate load reversals between measurements should be avoided. For the determination of stiffness and frictional energy dissipation, the frequency of cycling must be between 0.2 and 0.5 hertz.

Graphs of load versus displacement or velocity are desirable for the determination of the required stiffness or damping.

131

2.0. TESTS WITH THE WHEELS RESTRAINED

2.1. GENERAL

In the tests described in this section, the wheels are rigidly attached to the rails or supporting structure and the frame is moved relative to them.

The methods described are not suitable for trucks having steering links, which couple the lateral or roll motion of the body or truck frame to the yaw motion of the axles. In such a case, provision must be made for unrestrained longitudinal movement of the wheels, discussed in section 3. The steering links may be disconnected to measure the characteristics of suspension elements in the unsteered condition.

All tests require that the actuators and restraining links, other than those at the wheels, have the equivalent of ball joints at both ends to allow for motion perpendicular to their axis.

2.2. VERTICAL SUSPENSION STIFFNESS

For this test, equal measured vertical loads are applied across the spring groups in the range from zero to 1.5 times the static load, if possible, and at least to the static load of the fully loaded car. Vertical actuators are attached to each side of the body or the structure simulating it. The load may also be applied by adding dead load or a combination of both dead and actuator loads.

Vertical deflections are required across all significant spring elements under load. It is important to report any differences in the measurements taken between each axle and frame or sideframe.

2.3. TOTAL ROLL STIFFNESS

A roll test is required if the roll characteristic between the body and axle includes movement at or forces due to elements other than the vertical suspension, such as clearances at sidebearings, or anti-roll bars.

For the roll test, two vertical actuators are required as in the vertical test, but with the loads in the actuators in opposite directions. The range of roll moments, in inch-pounds, applied to the truck should be between plus and minus 30 times its static load, in pounds, or until the wheels lift. The roll angle across all suspension elements may be measured directly or deduced from displacements.

2.4. TOTAL LATERAL STIFFNESS

The lateral stiffness characteristic may be found by attaching an actuator to apply loads laterally to the body or bodies, which should be positioned as if on tangent track. If the lateral motion of the truck frame is coupled to its yaw through a steering mechanism, it should be disconnected to prevent the yaw resistance of the frame from affecting the measurement of lateral stiffnesses.

The minimum and maximum lateral loads applied per truck should be minus and plus one fifth of the static load carried. Measurements are required of the lateral displacements across all suspension elements.

2.5. INTER-AXLE TWIST AND EQUALIZATION

This test is carried out with only one axle fixed to the track. One wheel of the other axle in the car or truck is jacked up to a height of 3 inches, and the vertical load and displacement are measured. The stiffness between the axles in twist is the ratio of the load to the displacement multiplied by the square of the gage. It is a measure of the truck equalization.

3.0. TESTS WITH UNRESTRAINED WHEELS

3.1. GENERAL

These tests involve movements in the suspension system and axles relative to other elements of the system or to other axles, without restraint between the wheel and rail, but with the normal static vertical load.

The shear resistance between the rail and the wheel must be eliminated by the provision of a device having very low resistance, such as an air bearing, under each axle.

3.2. AXLE ALIGNMENT

Both radial and lateral misalignments may be deduced from measurements of the yaw angle of each axle from a common datum. The radial misalignment between axles is half the difference in their yaw angles, taken in the same sense, and the lateral misalignment is their mean yaw angle.

In the case of trucks which have significant clearance between the axle and frame, it may be necessary to establish the axle in the center of the clearance for the purpose of identifying the mean axle misalignments.

3.3. LONGITUDINAL STIFFNESS

A longitudinal load must be applied to the axle, equivalent to a single load at its center, and cycled between tension and compression up to half the static load on the axle.

The load may be applied directly between axles, or between the test axle and ground through an appropriate structure, with the body or truck frame restrained. The load may also be applied directly between the axle and frame, or in the case of a car with single axle trucks, between the axle and the body.

The longitudinal deflection across each spring element must be measured and the results plotted.

Where the load is applied directly between the axles of a truck or car, this measurement may be combined with the inter-axle shear test in section 3.4., or the inter-axle bending stiffness test in section 3.5.

3.4. AXLE LATERAL AND INTER-AXLE SHEAR STIFFNESS

The inter-axle shear stiffness may be found by shearing the axles, or moving them in opposite directions along their axes, and measuring the shear or lateral deflection between them. The shear force on each axle must be at least one tenth of the static vertical axle load.

This test may be combined with the inter-axle longitudinal test of section 3.3., where the required load can be achieved.

In the case of direct inter-axle loading, the locations of the applied force and restraint are such that they are equal and opposite, diagonally across the truck or car.

The actuator and restraint each provide two components of force on the axle to which they are attached. One component lies along the direction of the track and provides tension and compression, as in section 3.3., for the longitudinal stiffness. The other component lies along the axle and applies the required shear force bewteen axles. This component may be applied separately with a suitable arrangement of actuators and restraints.

Measurements are made of the lateral misalignment of the axles during the load cycle. The shear stiffness is the ratio of shear force to the lateral misalignment.

For single axle trucks, a test similar to that described above may be used to determine the lateral stiffness, with force applied laterally between ground and the axle with the body restrained, or with the truck frame restrained in the case of trucks having more than one axle. For trucks which also provide steering through coupling axle lateral motion to its yaw angle, this test may be preferred over the lateral test of section 2.4. for finding the lateral stiffness, since the axles are free to yaw.

3.5. AXLE YAW AND INTER-AXLE BENDING STIFFNESS

The inter-axle bending stiffness may be found by yawing the axles in the opposite directions and measuring the yaw angle between them. The yaw moment applied, in inch-pounds, must be at least equal to the axle load in pounds.

This test may be combined with the inter-axle longitudinal test of section 3.3. If this is done, the test is carried out by applying an effective force on the axle a known distance laterally from the truck centerline.

In the case of direct inter-axle loading the restraint must be applied to the axle, at the other end of the car or truck, on the same side as the applied force. The applied and restraining forces each provide a longitudinal force and a yaw moment on the axle to which they are attached. The force provides the tension and compression as in section 3.3. for the longitudinal stiffness and the moment is applied between the truck axles in yaw. This moment may be applied independently of the longitudinal force.

Measurements are made of the resulting radial mis-alignment of the axles during the load cycle. The bending stiffness is the ratio of applied bending moment to the radial misalignment.

A similar test of the axle yaw stiffness may be arranged with forces applied in yaw between a single axle and ground, with the body restrained, or with the truck frame restrained in the case of trucks having more than one axle.

3.6. YAW MOMENT BETWEEN THE SUSPENSION AND BODY

The required yaw stiffness and breakout torque between the car body and truck must be measured by applying a yaw moment, using actuators in equal and opposite directions at diagonally opposite corners of the truck to rotate the truck in yaw. The car body must be restrained.

The applied yaw moment must be increased until gross rotation is observed, representing the breakout torque, or to the limit recommended for the yaw of the secondary suspension.

The angle in yaw between the car body and truck bolster or frame must be measured.

4.0. RIGID AND FLEXIBLE BODY MODAL CHARACTERISTICS

4.1. GENERAL

Tests are required to identify the rigid and flexible body modal frequencies and damping. The rigid body modal frequencies may be compared to predictions using estimated or measured body masses, and inertias and the suspension parameters measured according to the requirements of sections 2. and 3. Tests and estimates should be made with the car in the empty and fully loaded state.

4.2. TEST CAR BODY

For cars consisting of more than one coupled unit, tests for body modes are required on one of each of the unit bodies having a different structural design. Dead loads may be added to give the required additional loading to any shared suspensions.

Where coupling exists between the modes of adjacent bodies, such as in roll or torsion, this may be examined in a dynamic analysis, validated for the case of tests without coupling.

The frequency and modal damping are only required for the flexible body modes which are predicted to have a natural frequency below 12 hertz.

4.3. GENERAL PROCEDURE

Transient or continuous excitation may be applied, using one or more actuators or dropping the car in a manner to suit the required mode of excitation.

The modal frequency and damping are required for an amplitude typical of the car running on class 2 track.

In the case of the rigid body modes, the actuators must be located at the rail level or the level of the truck frame with the body free to oscillate on its suspension. In the case of the flexible body modes, the excitation may be applied directly to the body.

The frequency in hertz may be determined from the wavelength in the transient test, or from the peak response, or from the 90 degree phase shift between the response and excitation where continuous excitation is used.

The percentage modal damping may be determined using the logarithmic decrement in transient tests or the bandwidth of the response from a range of frequencies.

4.4. RIGID BODY MODES

The rigid body modes for the car are:

Body bounce
Body pitch
Body yaw and sway
Lower center roll
Upper center roll

In the case where the normal load on the body is not centered between the suspensions, the body bounce mode may be coupled to the body pitch. The required measurement of bounce and pitch may be achieved by two vertical measurements at the ends of the car. Their weighted sum provides bounce and their weighted difference pitch. The weighting is dependent on their position relative to the center of mass.

Yaw and sway are deduced from lateral measurements made at each end of the body, a known distance from its mass center, similarly to the determination of pitch.

Measurement of the upper and lower center roll modes are determined from lateral displacements taken at two heights, or by a single lateral displacement and a roll angle measurement.

4.5. FLEXIBLE BODY MODES

The flexible body modes for the car are:

Torsion
Vertical bending
Lateral bending

Determination of the frequency and damping in the torsion mode requires excitation and measurement of roll at one end of the car.

The excitation is similar to that for roll but resonance occurs at a higher frequency. The response between the ends of the car is out of phase for modes number 1,3, and in phase for modes number 2,4, although it is unlikely that modes above 2 will be significant.

Vertical or lateral bending modes are measured as a response to the vertical or lateral excitation at one end or both ends of the car. The first bending mode has a maximum amplitude at or near the car center. The second bending mode has a node or point of minimum response at the center.

5.0. PARAMETER ESTIMATION*

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* Tests are presently being conducted to examine this method.

APPENDIX B

SPECIFICATION FOR INSTRUMENTED WHEELSETS FOR CHAPTER XI (M-1001) TESTING

Adopted 1989

1.0. INTRODUCTION

Instrumented wheelsets to be used in acceptance testing of new and untried cars under Chapter XI of AAR Standard M-1001 must meet the requirements of this specification. Load measuring wheelsets are a critical transducer for a wide range of the Chapter XI vehicle dynamics tests. Calibrated wheelsets will be required to accurately measure lateral and vertical wheel/rail forces, as well as wheel lateral to vertical force (L/V) ratios. A verification of wheelset accuracy is performed through a three-step process consisting of calibration, analysis, and field procedures.

2.0. INSTRUMENTED WHEELSET SPECIFICATIONS

To be accepted for Chapter XI testing, a load measuring wheelset design must meet the following specifications:

2.1.

Vertical wheel load measurements must be within +/− 5 percent of the actual vertical load. This accuracy is to be maintained for loads ranging from 0 to 200 percent of the static wheel load. The minimum signal resolution is to be no less than 0.5 percent of the static wheel load.

2.2.

Lateral wheel load measurements must be within +/− 10 percent of the actual lateral load. This accuracy is to be maintained for loads ranging from 0 to 100 percent of the static (vertical) wheel load. The minimum signal resolution is to be no less than 0.5 percent of the static (vertical) wheel load.

2.3.

Maintain the above stated accuracy requirements, at all times, for:

2.3.1.

All potential load cases (longitudinal loads of up to 60 percent of the static (vertical) wheel load, lateral loads of up to 100 percent of the static (vertical) wheel load, and vertical loads of up to 200 percent of the static wheel load).

2.3.2.

All potential wheel/rail contact conditions including full flange contact, outside tread contact, two-point contact, and flange contact at high wheelset angles of attack.

2.3.3.

An operating speed (for dynamic wheelset output) of from 5 to 80 mph.

2.3.4.

Signals from 0 to 30 Hertz.

137

2.3.5.

Over a recommended operating ambient temperature range of 0 to 110 degrees Fahrenheit. Any restrictions in the operating temperature range are to be noted.

2.4.

Wheelset reprofiling or recalibration requirements due to profile wear are to be documented. Temperature compensation arrangements and operating limitations due to ambient temperature swings are to be detailed as well. The wheelsets are to be equipped with the modified Heumann profile shown in Figure 8.1 of Chapter VIII of AAR Standard M-1001.

3.0. VERIFICATION

Wheelset accuracy is to be substantiated through calibration, analysis, and testing. A minimum number of required wheelset static tests to calibrate and verify wheelset output are described. Since dynamic calibration of load measuring wheelsets has proven difficult, further verification of wheelset accuracy relies on required static and dynamic analyses. A limited set of simple experimental procedures are then prescribed to confirm proper wheelset function under field conditions.

3.1. STATIC CALIBRATION

Static tests to determine the wheelset calibration factors are required of all instrumented wheelsets. Documentation in support of the calibration tests is to include a complete description of the calibration stand and the calibration procedure. Calibration for vertical and lateral loads is to include testing for a minimum of six wheel rotational positions (0, 60, 120, 180, 240, and 300 degrees). Calibration for vertical loads is to include testing for a minimum of three contact point lateral positions (on tape line and one inch), respectively, to the flange and wheel face of the tape line. Each calibration sequence is to be repeated at least once to verify measurement repeatability.

The static calibration tests are as follows:

3.1.1.

Using an appropriate loading scheme, vertical loads ranging from 0 to 200 percent of the static wheel load are to be applied with a minimum of 5 equally spaced inputs (0, 50, 100, 150, and 200 percent of the static wheel load). Strain gauge output for both vertical and lateral force circuits is to be recorded.

3.1.2.

Using an appropriate loading scheme, lateral wheel loads are to be applied at the wheel tread ranging from −100 to 100 percent of the static wheel load with a minimum of 10 equally spaced inputs (+/− 20, 40, 60, 80, and 100 percent). A vertical force equivalent to the static wheel load is to be applied simultaneously. Both vertical and lateral force strain gauge outputs are to be recorded.

The static calibration report is to include raw measurement values and the derived calibration factors. The calibration report must also include a table comparing the applied forces and, given the calibration factors obtained during the testing, the measured forces. It is assumed here that the calibration factors will represent average values independent, for example, of wheelset rotational position.

3.2. ANALYSIS

The following theoretical analyses are required to verify theoretical wheelset accuracy for load combinations that cannot satisfactorily be applied using a conventional static loading frame. It is assumed that finite element or similar calculations will have been performed beforehand to obtain the theoretical wheelset calibration factors. Any variations in wheelset output or accuracy due to rotational position are to be described.

Static finite element or similar calculations to verify theoretical wheelset accuracy for the following scenarios:

3.2.1.

Single point contact at one inch toward the wheel face from the wheel tape line for a vertical load of 50 and 200 percent of the static wheel load in combination with a lateral load of −25 and 25 percent of the static wheel load (giving a total of four load combinations).

3.2.2.

Single point contact on the flange (defined as being at a point giving a rolling radius one-half inch greater than that obtained at the tape line) for a vertical load of 100 and 150 percent of the static wheel load in combination with a lateral load of 25, 50, and 75 percent of the static wheel load (giving a total of six load combinations).

3.2.3.

Single point contact at the wheel tape line for a vertical load equal to the static wheel load in combination with a longitudinal load of −50, −25, 25, and 50 percent of the static wheel load and a lateral load of 10 percent of the static wheel load (for a total of four load combinations). Note that a negative longitudinal load is defined here as a load directed in the sense of the wheel rotation.

3.2.4.

Single point contact at the flange for a vertical load of 75 percent of the static wheel load in combination with a longitudinal load of −50, −25, 25, and 50 percent of the static wheel load and a lateral load of 50 percent of the static wheel load (for a total of four load combinations).

3.2.5.

Two-point contact with the first point of contact at one-half inch toward the wheel face from the wheel tape line and the second point of contact at the flange and displaced −0.5, 0, and 0.5 inches longitudinally from the mid-plane axis of the wheelset. The loading at the tread contact is to be a vertical load of 50 percent of the static wheel load in combination with a longitudinal load of −25 percent and a lateral load of −10 percent of the static wheel load. The loading at the flange contact is to be a vertical load of 75 percent of the static wheel load in combination with a longitudinal load of 50 percent and a lateral load of 50 percent of the static wheel load (for a total of three calculation cases).

3.2.6.

Single point contact at the tape line for a wheel with a radius one-quarter inch less than nominal and a vertical load equal to the static wheel load in combination with a lateral load of 10 percent of the static wheel load.

3.2.7.

Single point contact at the flange for a wheel with a radius one-quarter inch less than nominal and a vertical load equal to 75 percent of the static wheel load in combination with a lateral load of 50 percent of the static wheel load.

Results for the twenty-three static calculation cases described above are to be given as the percent deviation of the predicted lateral and vertical force values from the applied values.

A single dynamic finite element or similar calculation to verify theoretical wheelset accuracy under dynamic conditions:

3.2.8.

This calculation is to verify that no wheelset vibration modes are present with natural frequencies below 30 Hertz. If such modes exist, a dynamic calculation is to be performed for the following wheelset input: single point contact at the wheel tape line for a vertical load equal to the static wheel load in combination with a time varying longitudinal load with an amplitude of 25 percent and a lateral load with an amplitude of 10 percent of the static wheel load. The mean longitudinal and lateral force are both to be zero. The calculation is to consider an input frequency ranging from 0 to 30 Hertz where the lateral and longitudinal force signals are 90 degrees out of phase. The boundary condition to be used for both this calculation and the wheelset natural frequency calculation is to fix the wheelset in the longitudinal, lateral, vertical, and rotational sense at the bearing centerline (axle top dead center).

The results of the dynamic calculation are to be given as the mean value and amplitude of the predicted lateral and vertical forces as functions of the wheelset rotational position.

3.3. TEST PROCEDURES

The following experimental analyses are required:

3.3.1.

A zero speed jacking test to set the wheelset zero followed by a slow speed roll (at ten, twenty, and thirty miles per hour) along tangent track to verify that wheel vertical load signals are within +/− 5 percent of the calibrated scale axle load for constant speed operation on level tangent track. Wheelset signals will be evaluated on the basis of mean values for a randomly chosen output segment having a minimum duration of ten seconds.

3.3.2.

A steady-state curving test to confirm that net truck or car lateral loads are within +/− 10 percent of the theoretical value for constant speed operation on constant radius track at speeds corresponding to +3, 0, and −3 inches cant deficiency. Both curvature and superelevation of the track need to be constant and accurate. Wheelset accuracy is to be verified on a sharp curve (7 degrees curvature and above) for curving with hard flange contact. Wheelset signals will be evaluated on the basis of mean values for a randomly chosen output segment having a minimum duration of ten seconds.

3.3.3.

As an alternative to this test a zero speed jacking test is suggested using equal and opposing lateral loads applied (via a hydraulic jack) to the wheel backs. Measured lateral loads are to be within +/− 5 percent of the applied value for loads ranging from 0 to 50 percent of the static (vertical) wheel load.

3.3.4.

A steady-state curving test to again confirm that total truck vertical loads are within +/− 5 percent of the theoretical value for constant speed operation on constant curvature track (for the test curve described above). Wheelset signals will be evaluated on the basis of mean values for a randomly chosen output segment having a minimum duration of ten seconds.

The test procedures prescribed above are also to be repeated and recorded at the start of each Chapter XI test series. A record of such results is to be kept for each Chapter XI certified wheelset. A minimum of the vertical load accuracy test is to be performed at the start of each daily test session.

4.0. RECORDS

4.1.

The theoretical analyses described are necessary only once for each wheelset design. The static calibration and field procedures must be performed for each wheelset produced to an accepted specification.

4.2.

An instrumented wheelset which has met these requirements will be so certified by the designated AAR representative.

4.3.

The designated AAR observer for Chapter XI testing will verify that the instrumented wheelsets to be used have been accepted for testing and the test procedures described in Section 3.3 above are completed satisfactorily.

APPENDIX C

TRIPLET TRACK WORTHINESS TEST PROCEDURES
AND
TRIPLET TRACK WORTHINESS SETUP PROCEDURES

(1) ON-TRACK TEST PHASE I
(2) ON-TRACK TEST PHASE I TEST SETUP
(3) ON-TRACK TEST PHASE II
(4) ON-TRACK TEST PHASE II TEST SETUP

143

(1)

PEACEKEEPER RAIL GARRISON PROCEDURE PKRG-7000-TRIPLET CARS ON-TRACK TRIPLET TEST PHASE I

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-7000-TRIPLET CARS
ON-TRACK TEST PHASE I

1.0 DESCRIPTION

This procedure outlines the sequence of steps to conduct On-Track Triplet Test, Phase I Testing at the Transportation Test Center (TTC). The On-track Testing consist of seven sub-tests:

1. Hunting Test
2. Constant Curving Test
3. Spiral Negotiation Test
4. Rock and Roll Test
5. Pitch and Bounce Test
6. Dynamic Curving Test
7. Yaw and Sway Test

Additionally, two tests have been added for the Rail Garrison program, they are:

1. Turnout And Crossover
2. Wayside Measurement

1.1 INDEX

1.2 EQUIPMENT LIST

a.	4ea.	IITRI Instrumented Wheel Sets
b.	2ea.	ENSCO Instrumented Wheel Sets
c.	2ea.	Single Roll Gyrometer
d.	2ea.	Lateral Accelerometer
e.	6ea.	Strip Chart Recorder
f.	1ea.	Digitizer
g.	4ea.	100-Ton Jacks
h.	1ea.	HP 360 Data Acquisition System
i.	159ea.	Signal Conditioner
j.		All Safety Equipment As Required By TTC

1.3 FIGURE LIST

1.4 TABLE LIST

1.5 REFERENCE LIST

PRKG 2100....	Truck Inspection Procedure
PKRG 3100....	Instrument Installation Procedure
M1001........	Manual of Standards and Recommended Practices, Section C, Part II, Volume I, Chapter XI
PKRG 3300.....	ENSCO 38" Instrumented Wheel Sets Installation, Calibration and Operation
PKRG 3400.....	IITRI 38" Instrumented Wheel Sets Installation, Calibration and Operation
PKRG 3500.....	IITRI 36" Instrumented Wheel Sets Installation Calibration and Operation

PKRG 3800-TC	On-track Test Setup Phase I
PKRG 7001.....	Test Sequence Chart
PKRG 7002.....	Daily Pre-test Sign-off Sheet
PKRG 8100.....	Loading/Unloading Procedure for 36" Triplet Cars
M1001	Manual of Standards and Recommended Practices, Section C, Part II, Volume I, Chapter XI
	TTC Operation Rules for the Transportation Test Center, Pueblo, Colorado, AAR, November 1, 1989
	Peacekeeper Rail Garrison Test Implementation Plan, (for appropriate test car), Chapter XI testing
	ENSCO Operating Manual
	IITRI Operating Manual
	TTC Safety Rule Book

1.6 TEST DOCUMENTATION LIST

NONE

NOTE

All personnel involved in the performance of this procedure or observing the test(s) will comply with the TTC Safety Rule Book.

2.0 PRE-TEST FOR ALL TESTS (EXCEPT YAW AND SWAY)

2.1 38" Instrumented Wheel Set Installation

TASK NUMBER	PROCEDURE	QA INITIAL
2.1.1	Disconnect the hand brake chain and air brake line.	
2.1.2	Ensure brake shoes and keys are removed from each wheel location.	
2.1.3	Remove all slack adjusters.	
2.1.4	Secure emergency brake chain.	
2.1.5	Remove and secure all loose brake system components. Mark the removed components defining location from which they were removed and store components for later reinstallation.	
2.1.6	Chock all B-end wheels.	
2.1.7	Using two 100-ton jacks at the jacking pad, jack the test car up approximately 12 inches to remove the A-end running gear assembly.	
2.1.8	Roll the span bolster and trucks away from the car.	
2.1.9	Lift the front of the span bolster and place on blocks.	

2.1.10 Roll out Truck 4.

2.1.11 Lift Truck 4 and remove the leading Axle 8 wheel set.

2.1.12 Replace the leading wheel set with the IITRI WS 17 Instrumented Wheel Set in accordance with, PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3800-TC On-track Test Phase I.

2.1.13 Roll the truck back under the span bolster.

2.1.14 Lower the span bolster.

2.1.15 Lift the rear of the span bolster and place on blocks.

2.1.16 Roll out Truck 3.

2.1.17 Lift Truck 3 and remove wheel set (Axle 6).

2.1.18 Replace the leading wheel set with the ENSCO WS 1 Instrumented Wheel Set in accordance with, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG- 3800-TC On-track Test Phase I.

2.1.19 Roll the truck back under the span bolster.

2.1.20 Lower the span bolster and replace the running gear assembly.

2.1.21 Lower the jacks.

2.1.22 Repeat Steps 2.1.1 through 2.1.21 for the B-end running gear assembly; using IITRI WS 18 under Truck 2 (Axle 4) and ENSCO WS 2 under Truck 1 (Axle 2).

2.1.23 Quality verify the completion of the wheel set change out. ______

3.0 36" INSTRUMENTED WHEEL SET INSTALLATION PROCEDURE

3.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
3.1.1	Disconnect the hand break chain and air brake line on the lead Triplet Car.	______
3.1.2	Ensure brake shoes and keys are removed from each wheel location.	
3.1.3	Remove all slack adjusters.	
3.1.4	Secure emergency brake chain.	
3.1.5	Remove and secure all loose brake system components. Mark the removed components defining location in which they were removed and store components for later installation.	
3.1.6	Chock all A-end wheels.	
3.1.7	Using two 100-ton jacks at the jacking pad, jack the test car up approximately 12 inches to remove the B-end running gear assembly.	
3.1.8	Roll the span bolster and trucks away from the car.	

3.1.9 Lift the front of the span bolster and place on blocks.

3.1.10 Roll out Truck 2.

3.1.11 Lift Truck 2 and remove the leading Axle 4 wheel set.

3.1.12 Replace the leading wheel set with the 36" IITRI Instrumented Wheel Set in accordance with the PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation and PKRG- 3800-TC On-track Test Phase I.

3.1.13 Roll the truck back under the span bolster.

3.1.14 Lower the span bolster and replace the running gear assembly.

3.1.15 Lower jacks.

3.1.16 Quality verify the completion of the wheel set change out as shown in Figure 3-1.

3.1.17 Repeat all 36" Instrumented Wheel Set Installation Procedures for next 36" Wheel Set Triplet Car, replacing Truck 4 (Axle 8) with the IITRI 36" Instrumented Wheel Set.

3.1.18 Quality verify the completion of the wheel set change out as shown in Figure 3-1. ______

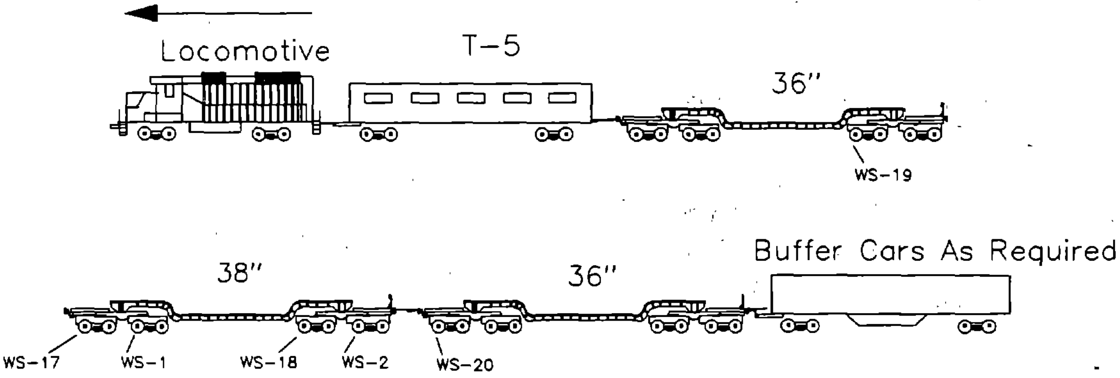

Figure 3-1 36" and 38" Instrumented Wheel Set Configuration

3.2 Coupling of the Test Car and the Instrumentation Car

TASK NUMBER	PROCEDURE	QA INITIAL
3.2.1	Couple the A-End of the Triplet Cars behind the instrumentation car; then, couple 6 loaded 100-ton buffer cars to the Triplet Cars. Figure 3-2 shows the core test consist.	

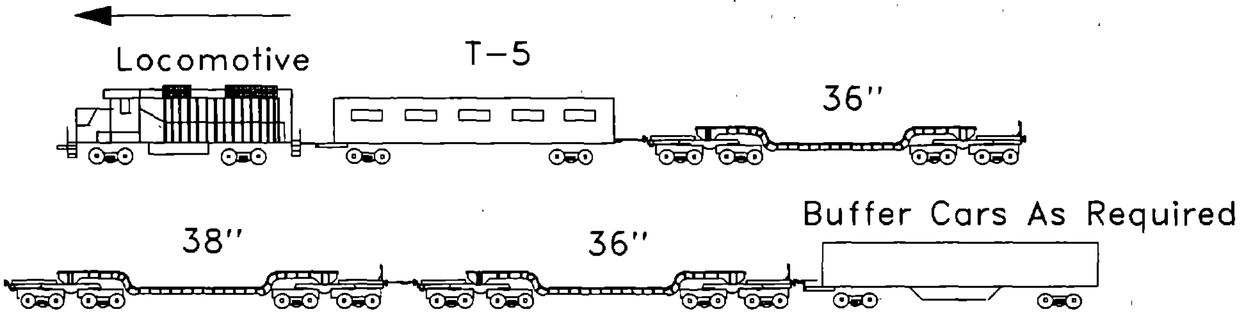

Figure 3-2 Core Test Consist

CAUTION

Restrict coupling speed to 3.5 mph

3.3 38" Instrumentation Checkout

TASK NUMBER	PROCEDURE	QA INITIAL
3.3.1	Calibrate instrumentation in accordance with PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3800-TC On-track Test Phase I.	
3.3.2	Quality verify coupling of the Triplet Cars and the Instrumentation Car is complete.	______

3.4 36" Instrumentation Checkout

TASK NUMBER	PROCEDURE	QA INITIAL
3.4.1	Calibrate instrumentation in accordance with PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3800-TC On-track Test Phase I.	
3.4.2	Quality verify coupling of the Triplet Cars and the Instrumentation Car is complete.	______

4.0 TEST SETUP

TASK NUMBER	PROCEDURE	QA INITIAL
4.0.1	Calibrate instrumentation in accordance with PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation.	
4.0.2	Calibrate instrumentation in accordance with PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation.	

4.0.3	Quality verify coupling of the Triplet Cars and the Instrumentation Car is complete.	______

NOTE

Test sequence is arbitrary. The test sequence may bedictated by track availability at TTC.

5.0 LATERAL STABILITY ON TANGENT TRACK (HUNTING)

5.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
5.1.1	Ensure that buffer cars are coupled to the core test consist as illustrated in Figure 3-2.	______
5.1.2	Ensure that instrumentation meets the requirements outlined in PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation, and PKRG-3800-TC On-track Test Phase I.	______
5.1.3	Ensure that instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation, and PKRG-3800-TC On-track Test Phase I.	

5.2 On-track Test

TASK NUMBER	PROCEDURE	QA INITIAL
5.2.1	Ensure that the instrumentation is checked-out in accordance with Steps 3.1.1 through 3.3.2 and 3.4.1 through 3.4.2.	

NOTE

Test to be conducted on 5,000 feet of dry tangent track on the RTT with Class 5 or better track (R39-R33).

CAUTION

Stop testing when lateral acceleration exceeds 1.0 g peak to peak or any maximum axle sum L/V exceeds 1.3 for 50 millisecond.

5.2.1.1 Ensure applicable perturbations have been verified. ______

5.2.1.2 Ensure pretest sign off sheet PKRG-7002 has been completed. ______

5.2.2 During the initial 30 mph track conditioning run, keep the speed constant through the test zone.

5.2.3 Start acquiring lateral acceleration data 200 - 300 ft. before reaching the test zone. The computer should be triggered by Automatic Location Device (ALD).

5.2.4 Stop data acquisition 200 - 300 ft. beyond the test zone.

5.2.4.1 Review test, ensure data is acceptable and indicates that the test can be continued.

5.2.5 Repeat test once.

5.2.5.1 Compare maximum limiting values. Ensure readings are within 15 percent of each other. For instrumented wheel sets, 5 percent on roll gyros and accelerometers.

5.2.6 Increase speed in increments of 10 mph, +/- 1 mph, with each pair of test runs, until approaching a critical point (80 percent of stop criteria) (.8 g peak to peak, 1.0 L/V); then, increase speed in increments of 2 mph until a maximum test speed of 70 mph is reached.

5.2.7 In the Test Engineer's Log, note the speed at which the car sustains truck hunting, if hunting occurs. (Per Chapter XI criteria 1.0 g peak to peak for 20 seconds). _____

5.2.8 Quality verify that the test is completed. _____

5.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
5.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3800-TC.	_____
5.3.2	Perform Post Test Visual Inspection.	_____

6.0 CONSTANT CURVING TEST

6.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
6.1.1	Instrumentation for this test should be as per Section 2.0.	
6.1.2	Ensure that instrumentation meets the requirements outlined in PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3800-TC On-track Test Phase I.	_____

6.1.3 Ensure that instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Instrumented Wheel set Installation, Calibration, and Operation, and PKRG-3800-TC On-track Test Phase I.

6.1.4 Ensure that buffer cars are coupled to the core test consist as illustrated in Figure 3-2.

CAUTION

Restrict coupling speed to 3.5 mph.

6.2 On-track Testing

TASK NUMBER	PROCEDURE	QA INITIAL
6.2.1	This test utilizes three different degrees of curvature and superelevation (7.5-, 10-, and 12- degree with 4, 3.4 and 5 inches of superelevation respectively) available on the WRM track.	
6.2.1.1	Ensure applicable perturbations have been verified.	_____
6.2.1.2	Ensure pre-test sign off sheet PKRG-7002 has been completed.	_____

6.2.2 Determine the test run speed by equation:

$$V = \sqrt{1480\frac{(U+H)}{D}}$$

Where: U = unbalance in inches
H = superelevation in inches
D = degree of curvature

Where: U= _____
H= _____
D= _____

6.2.3 For U = -3. 0, and 3 inches of unbalance.

157

NOTE

Track speed may be lower than the calculated speed for the +3 inches. If this condition exists use the track speed limit of 45 mph. The speed calculate for the -3 inches may be zero or less. If this condition exists use a negative difference from the balance equal to the positive difference for the +3 inches.

CAUTION

Stop testing when any L/V exceeds 0.8 or any axle sum L/V exceeds 1.3 for a period greater than 200 millisecond.

6.2.4 Operate the test consist at a constant speed for each condition shown in Table 3-1 (speeds shall be +/- 1 mph).

Table 3-1 Constant Curving Conditions Matrix

DEGREE	SUPER ELEVATION	BALANCE SPEED	+3 INCH	-3 INCH
7.5	3	24.0	32.0	14.0*
10	3.4	24.0	32.0	12.0
12	5	25.0	32.0	16.0

This speed is -2 inch unbalance; -3 inch is 0 mph

6.2.5 With each test run, record data 200 - 300 ft. before the curve and through the length of the body of the curve. The computer should be triggered by the ALD.

6.2.5.1 Repeat Step 6.2.4 for opposite directions.

6.2.6 QA verify that the test matrix is complete. ______

6.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
6.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3800-TC.	______
6.3.2	Perform Post Test Visual Inspection.	______

7.0 SPIRAL NEGOTIATION AND WHEEL UNLOADING

7.1 Test Requirements

TASK NUMBER	PROCEDURE	QA INITIAL
7.1.1	This test will run concurrently with the Constant Curving Test.	
7.1.2	Ensure applicable perturbations have been verified.	______
7.1.2.1	Ensure pre-test sign off sheet PKRG-7002 has been completed.	
7.1.3	Record data while running through the spirals on the WRM during the curving test.	

CAUTION

Stop testing when the vertical wheel force is less than
10 percent static wheel load or any wheel L/V exceeds 0.8 for 50 millisecond.

TASK NUMBER	PROCEDURE	QA INITIAL
7.1.4	QA verify that the test is complete.	______

8.0 TWIST AND ROLL TEST

8.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
8.1.1	Ensure that buffer cars are coupled to the core test consist as shown in Figure 3-2.	
8.1.2	Ensure that instrumentation meets the requirements outlined in PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3800-TC On-track Test Phase I.	_____
8.1.3	Ensure that instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation, and PKRG-3800-TC On-track Test Phase I.	_____

8.2 On-track Testing

TASK NUMBER	PROCEDURE	QA INITIAL
8.2.1.	Ensure applicable perturbations have been verified.	_____
8.2.1.1	Ensure pre-test sign off sheet PKRG-7002 has been completed.	_____
8.2.1.2	This test will be performed on the Precision Test Track (PTT).	
8.2.3	Approach the test zone at a constant speed of 5 mph, +/- 1 mph.	

NOTE

ENSCO Wheel Set Data not valid below 10 mph.

8.2.4 Record the wheel forces, mean roll angle and differences in roll between the ends for each truck for approximately 200 ft. before the test zone and continuously through the test zone.

CAUTION

Stop testing before the car body peak-to-peak roll exceeds 6 degrees, any single wheel L/V exceeds 0.8, any axle sum L/V exceeds 1.3 or any vertical wheel load measures less than 10 percent of its static wheel load.

8.2.5 Run tests at constant speeds, increasing in increments of 5 mph, +/- 1 mph until resonance is passed (expected resonance speed 13 mph calculated); then, increase speeds in increments of 5 mph.

8.2.6 Make two runs at each speed. In the Test Engineer's log, note the speed at which resonance is reached.

8.2.7 Stop testing if an unsafe condition is encountered or when the maximum speed of 60 mph is reached. _____

8.2.8 Quality verify that the Twist and Roll Test is completed. _____

8.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
8.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3800-TC.	_____
8.3.2	Perform Post Test Visual Inspection.	_____

8.4 Test Tear Down

TASK NUMBER	PROCEDURE	QA INITIAL
8.4.1	Remove the loaded buffer cars from the test consist, if necessary for next test regime.	
8.4.2	Quality verify that the Test Tear Down is completed.	_____

9.0 PITCH AND BOUNCE TEST

9.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
9.1.1	This test is to be preformed to the PTT located between stations 1716+00 and 1719+90.	
9.1.2	Ensure that the buffer cars are coupled to the core test consist as shown in Figure 3-2.	
9.1.3	Ensure that instrumentation meets the requirements outlined in PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3800-TC On-track Test Phase I.	_____
9.1.4	Ensure that instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation, and PKRG-3800-TC On-track Test Phase I.	_____

9.2 On-track Testing

TASK NUMBER	PROCEDURE	QA INITIAL
9.2.1	Ensure applicable perturbations have been verified.	_____
9.2.1.1	Ensure pre-test sign off sheet PKRG-7002 has been completed.	_____
9.2.2	Approach the test section at a constant speed of 30 mph, +/- 1 mph. Start recording test data approximately 200 ft. before the test section and continuously through the test section.	
9.2.3	Using the information fed to the computer from the instrumented wheel sets, record the vertical wheel forces before and continuously through the test zone.	
	CAUTION Stop testing when any wheel shows a vertical load of less than 10 percent of its static load for 50 millisecond.	
9.2.4	Increase speed in increments of 5 mph until unsafe conditions are encountered, the resonance is passed or, a maximum of 60 mph is reached. Increments may be reduced to 2 mph when nearing resonance. Resonance is expected at 46 MPH.	_____
9.2.5	Run the test twice at each speed.	
9.2.6	Quality verify that the Pitch and Bounce Test is completed.	_____

9.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
9.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3800-TC.	______
9.3.2	Perform Post Test Visual Inspection.	______

10.0 DYNAMIC CURVING TEST

10.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
10.1.1	This test is to be conducted on the 10 degree curve (station 1+00 to 3+50) of the wheel/rail mechanism (WRM) track.	
10.1.2	Ensure that instrumentation meets the requirements outlined in PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3800-TC On-track Test Phase I.	
10.1.3	Ensure that instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation, and PKRG-3800-TC On-track Test Phase I.	

10.2 On-track Testing

TASK NUMBER	PROCEDURE	QA INITIAL
10.2.1	Ensure TDM predictions have been completed.	______

10.2.2 Ensure applicable perturbations have been verified. ______

10.2.3 Ensure pre-test sign off sheet PKRG-7002 has been completed. ______

CAUTION

It shall be regarded as unsafe if a wheel lifts, if any wheel L/V exceeds 0.8, if the instantaneous sum of the absolute L/V values of the individual wheels on any axle exceeds 1.3, or the car body roll exceeds 6 degrees peak-to-peak or minimum wheel load of 10 percent static. Stop the test before any of these conditions exist.

10.2.4 Approach the test zone at a constant speed of 5 mph.

NOTE

ENSCO data not valid at speeds less than 10 mph.

10.2.5 Start acquiring test data approximately 200 ft. before the test zone. Record the lateral and vertical wheel forces and the roll angle.

10.2.6 Increase speed in increments of 2 mph until a maximum 32 mph is reached or an unsafe condition is encountered. ______

10.2.7 Quality verify that the Dynamic Curving Test is completed. ______

10.3 Post Test

TASK NUMBER **PROCEDURE** **QA INITIAL**

10.3.1 Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3800-TC. ______

10.3.2 Perform Post Test Visual Inspection. ______

10.4 Test Tear Down

TASK NUMBER	PROCEDURE	QA INITIAL
10.4.1	Remove the loaded buffer cars from the test consist, if necessary for next test regine.	
10.4.2	Quality verify that the Test Tear Down is completed.	_____

11.0 TURNOUT AND CROSSOVER TEST

11.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
11.1.1	Use whatever configuration the consist is in while traversing from one test section to the other.	
11.1.2	Ensure applicable perturbations have been verified.	_____
11.1.3	Ensure pre-test sign off sheet PKRG-7002 has been completed.	_____
11.1.4	This test will be performed on the turnouts and crossover on the RTT and TTT near Post 85.	
11.1.5	The Triplet Cars shall be run at 5 mph or less through a #7 car crossover with 13 feet track centers and through a 350 feet radius curve. The Triplet shall be stopped on the curve and the minimum clearance from strikers to coupler measured.	

12.0 SPECIAL PERTURBATIONS

12.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
12.1.1	If necessary, the consist may be run through special perturbations to be identified later.	
12.1.2	Test setup will be defined at that time.	

12.2 On-track Test

TASK NUMBER	PROCEDURE	QA INITIAL
12.2.1	Test procedure and stop criteria will be identified later.	

12.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
12.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3800-TC.	
12.3.2	Perform Post Test Visual Inspection.	

13.0 YAW AND SWAY TEST

13.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
13.1.1	This test is to be conducted on section 21+00 to 26+00 of the PTT.	

13.1.2 Reconfigure the 38" instrumented wheel sets by repeating Steps 2.1.1 through 2.1.22 moving the Instrumented Wheel Sets from Axle 6 to Axle 7 and moving the Instrumented Wheel Set from Axle 2 to Axle 3 as shown in Figure 13-1.

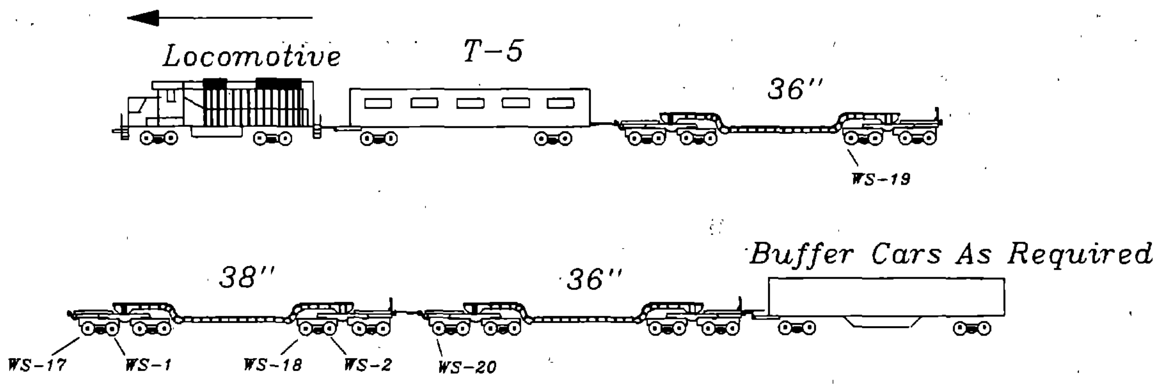

Figure 13-1 Core Test Consist

13.2 On-track Testing

TASK NUMBER	PROCEDURE	QA INITIAL
13.2.1	Ensure applicable perturbations have been verified.	______
13.2.2	Ensure pre-test sign off sheet PKRG-7002 has been completed.	
13.2.3	Ensure Instrumented Wheel Sets have been reconfigured as shown in Figure 13-1.	
13.2.4	The initial test run is to be conducted at a constant speed of 20 mph and increasing in increments of 5 mph, +/- 1 mph until resonance is passed, then increase at 5 mph +/- 1 mph.	
13.2.5	Begin test data acquisition approximately 200 ft. before reaching the test section.	

CAUTION

It shall be regarded as unsafe conditions if the ratio of the total lateral forces on any one side measured exceeds 0.6 for a duration equivalent to 6 ft. or any axle sum L/V exceeds 1.3 for 50 millisecond. Stop the test when either condition exists.

13.2.6 Repeat the test at speed increments of 2 mph, + /- 1 mph. The test will continue until an unsafe condition is encountered, the resonance is passed or the maximum speed of 60 mph is reached. Speed may be increased in increments of 5 mph when nearing resonance is passed. ______

13.2.7 Quality verify that the Yaw and Sway Test is completed.

13.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
13.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3800-TC.	______
13.3.2	Perform Post Test Visual Inspection.	

14.0 TEST CAR UNLOADING

TASK NUMBER	PROCEDURE	QA INITIAL
14.0.1	Unload car per Procedure-8100-Triplet Cars	

15.0 TEST TEAR DOWN

TASK NUMBER	PROCEDURE	QA INITIAL
15.0.1	The procedure for tear down of the ENSCO 38" Instrumented Wheel Sets is located in PKRG 3300, Section 5.0 through 5.1. Refer to this procedure and the applicable section to complete test tear down.	______
15.0.2	The procedure for tear down of the IITRI 38" Instrumented Wheel Sets is located in PKRG-3400, Section 6.0 through 6.1. Refer to this procedure and the applicable section to complete test tear down.	______
15.0.3	The procedure for tear down of the IITRI 36" Instrumented Wheel Set. Is located in PKRG-3500, Section 7.0. Refer to this procedure and the applicable section to complete test tear down.	______

16.0 QUALITY VERIFICATION

TASK NUMBER	PROCEDURE	QA INITIAL
16.0.1	Quality verified that Procedure PKRG-7000-Triplet Cars complete and closed.	
16.0.2	Authorized QA signature ____________________________.	

(2)

PEACEKEEPER RAIL GARRISON PROCEDURE PKRG-3800-TC ON-TRACK TEST PHASE I TEST SETUP

171

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-3800-TC
ON-TRACK TEST PHASE I TEST SETUP

1.0 DESCRIPTION

The purpose of this procedure is to outline the sequence of steps to be taken for the Rail Garrison On-Track Test Phase I Test Setup to be performed on three commercial span bolster cars (Triplet Cars).

1.1 INDEX

1.2 EQUIPMENT LIST

a.	4 ea.	38" Instrumented Wheel Set Systems
b.	2 ea.	36" Instrumented Wheel Set Systems
c.	8 ea.	Junction Boxes
d.	1 ea.	Automatic Location Detector

e.	1 ea.	Wheel Tachometer
f.	1 ea.	IRIG-B Time Code Receiver
g.	1 ea.	IRIG-B Decoder
h.	4 ea.	String Pot, +/- 1" range
i.	8 ea.	String Pot, +/- 5" range
j.	4 ea.	String Pot +/- 10" range
k.	22 ea.	Accelerometer +/- 5g range
l.	4 ea.	Accelerometer +/- 15g range
m.	3 ea.	Accelerometer +/- 25g range
m.	2 ea.	Rate Gyro +/- 8-degree range
o.	1 ea.	Instrumented Coupler, +/- 200 KIP range
p.	1 ea.	Thermocouple, - 50 to + 100 degree Fahrenheit
q.	2 ea.	Inclinometer, +/- 10-degree range
r.	2 ea.	Strain Gage Bending Bar, +/- 1" range
s.	1 ea.	HP 9000 model 360 Computer System
t.	1 ea.	HP 6944A Multi-programmer
u.	1 ea.	Dot X 205 Rail Test Vehicle
v.	As needed	Safety Equipment as required by TTC
w.	1 ea.	Instrumented Coupler, +/- 1,000 KIP range

1.3 FIGURE LIST

1.4 TABLE LIST

None

1.5 REFERENCE LIST

PKRG-2100	Truck Inspection Procedure
PKRG-2200	Car Inspection Procedure
PKRG-3100	Instrumentation Installation Procedure
PKRG-3200	Instrumentation Verification Procedure
PKRG-3300	ENSCO 38" Instrumented Wheel Set Procedure

PKRG-3500	IITRI 36" Instrumented Wheel Set Procedure
PKRG-3400	IITRI 38" Instrumented Wheel Set Procedure
AAR/TTC	Instrumentation SOP NO. 024 9/89
AAR/TTC	Rate Gyro Setup and Calibration Procedure
M1001	Manual Of Standards and Recommend Practices, C, Part II, Volume I, Chapter XI
	Instrum 2702 Signal Conditioner Setup Procedure
	TTC Operation Rules for the Transportation Test Center, Pueblo, Colorado, AAR, November 1, 1989
	Peacekeeper Rail Garrison Test Implementation Plan, (for appropriate test car), Chapter XI Testing

NOTE

All personnel involved in the performance of this procedure or observing the test(s) will comply with the TTC Safety Rule Book.

2.0 ON TRACK TESTING PHASE I TEST SETUP PROCEDURES

2.1 Test Setup Procedures

TASK NUMBER	PROCEDURE	QA INITIAL
2.1.1	Install instrumented wheel sets by following the instrumented wheel set procedures PKRG-3500, PKRG-3400 and PKRG-3300.	
2.1.2	Couple test vehicle and locomotive to the Dot X 205 Rail Test Vehicle as illustrated in Figure 2-1. Comply with TTC Operating Rules.	

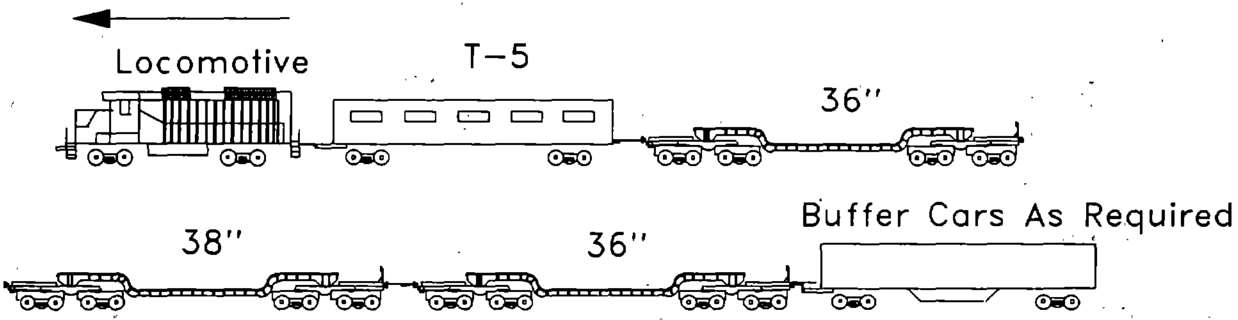

Figure 2-1 Vehicle Configuration

NOTE

Calibration procedures will be accomplished at the start of each test day for all the following tasks.

175

2.2 Instrumented Wheel Set Calibration Procedure.

TASK NUMBER	PROCEDURE	QA INITIAL
2.2.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.2.2	Refer to the appropriate instrumented wheel set procedure: PKRG-3500 Installation, Calibration and Operation of IITRI 36" Instrumented Wheel Sets. PKRG-3400 Installation, Calibration and Operation of IITRI 38" Instrumented Wheel Set Procedure and PKRG-3300 Installation, Calibration and Operation of ENSCO 38" Instrumented Wheel Set Procedure.	______
2.2.3	Print checkout values and label Pre-test Instrumented Wheel Set Zeros.	
2.2.4	Print checkout values and label Pre-test Instrumented Wheel Set RCAL.	
2.2.5	Quality verify wheel set calibration is complete.	______

2.3 Accelerometer Calibration Procedure for all Accelerometer Channels.

TASK NUMBER	PROCEDURE	QA INITIAL
2.3.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.3.2	Refer to Test Measurement List for layout (18 sheets attached at end).	
2.3.3	Install accelerometers in accordance with AAR/TTC Instrumentation SOP NO. 024 9/89 (attached at end).	______

2.3.4 Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Sections 8,9).

2.3.5 Monitor excitation and adjust excitation to voltage specified in the configuration data sheet to within +/- 10 mV.

2.3.6 Position the function knob to INPUT SHORT.

2.3.7 Adjust the DC offset of the conditioner to zero +/- 2 mV.

2.3.8 Position the function knob to DATA mode.

2.3.9 Adjust the balance pot for zero volts +/- 10 mV.

2.3.10 Place the function knob to the CAL mode position.

2.3.11 Verify cal output equals the configuration data sheet.

2.3.12 Place all accelerometers in the DATA mode, print out values and label Pre-test Accelerometer Zeros.

2.3.13 Place all accelerometers in the CAL mode, print out values and label Pre-test Accelerometer RCALS.

2.3.14 Place all accelerometer channels back to the DATA mode.

2.3.15 Quality verify all accelerometer calibration has been completed.

2.4 String Pot Calibration Procedure for all String Pots.

TASK NUMBER	PROCEDURE	QA INITIAL
2.4.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.4.2	Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Section 9).	______
2.4.3	Monitor the excitation and adjust to + 10.0 VDC +/- 5 mV.	
2.4.4	With the function knob in the INPUT SHORT position, adjust the DC offset of the conditioner to zero +/- 2 mV.	
2.4.5	Position the function knob to DATA mode.	
2.4.6	Adjust the balance pot for zero volts +/- 10 mV.	
2.4.7	With all the string pot channels in the DATA mode, print out values and label Pre-test String Pot Zero.	
2.4.8	Place all string pot channels in the CAL mode, then print out the values and label Pre-test String Pot RCALS.	
2.4.9	Place all string pot channels back to the DATA mode.	
2.4.10	Qualify verify completion of string pot calibration.	______

2.5 Rate Gyro Calibration Procedure for all Rate Gyros.

TASK NUMBER	PROCEDURE	QA INITIAL
2.5.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.5.2	Mount gyros onto gyro rotation platform. Mount gyro platform at appropriate locations.	
2.5.3	Ensure 28 volt gyro rotation power is on.	
2.5.4	Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Section 9).	______
2.5.5	Monitor the excitation voltage and adjust to +10.00 VDC +/- 10 mV.	
2.5.6	With the function knob in the INPUT SHORT position, adjust the DC offset of the conditioner to zero +/- 2 mV.	
2.5.7	Position the function knob to DATA mode.	
2.5.8	Adjust the balance pot for zero +/- 10 mV.	
2.5.9	With all the gyro channels in the DATA mode, print out values and label Pre-test Gyro Zero.	
2.5.10	Place all the gyro channels in the CAL mode, wait approximately one minute, then print out the values and label Pre-test Gyro RCALS.	
2.5.11	Place all gyro channels back to the DATA mode.	

2.5.12 Refer to AAR/TTC Rate Gyro Setup and Calibration Procedure and perform necessary steps for the gyro integrator unit.

2.5.13 Quality verify that all gyro calibration has been completed. ______

2.6 Strain Gaged Bending Beam Calibration Procedure for all Strain Gaged Bending Beams.

TASK NUMBER	PROCEDURE	QA INITIAL
2.6.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.6.2	Mount all strain gaged bending beams in accordance with AAR/TTC Instrumentation SOP NO. 024 9/89.	______
2.6.3	Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Section 6).	______
2.6.4	Monitor the excitation voltage and adjust to +10.00 +/- 10 mV.	
2.6.5	With the function knob in the INPUT SHORT position, adjust the DC offset of the conditioner to zero +/- 3 mV.	
2.6.6	Position the function knob to DATA mode.	
2.6.7	Adjust the balance pot for zero volts +/- 10 mV.	
2.6.8	With all the strain gaged bending beam channels in the DATA mode, print out values and label Pre-test Strain Gaged Bending Beam Zero.	

2.6.9 Place all the strain gaged bending beam channels in the CAL mode, then print out the values and label Pre-test Strain Gaged Bending Beam RCALS.

2.6.10 Place all strain gaged bending beam channels back to the DATA mode.

2.6.11 Quality verify all couplers and strain gages have been calibrated. ______

2.7 Inclinometer Calibration Procedure for all Inclinometers.

TASK NUMBER PROCEDURE QA INITIAL

2.7.1 Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8. ______

2.7.2 Mount all inclinometers.

2.7.3 Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Section 9). ______

2.7.4 Monitor the excitation voltage and adjust to + 10.00 mV.

2.7.5 With the function knob in the INPUT SHORT position, adjust the DC offset of the conditioner to zero + /- 2 mV.

2.7.6 Position the function knob to DATA mode.

2.7.7 Adjust the balance pot for zero volts + /- 10 mV.

2.7.8 With all the inclinometers channels in the DATA mode, print out values and label Pre-test Inclinometer Zero.

2.7.9 Place all inclinometer channels in the CAL mode, then printout the values and label Pre-test Inclinometer RCALS.

2.7.10 Place all inclinometer channels back to the DATA mode.

2.7.11 Quality verify inclinometer channels have been calibrated. ______

3.0 ON-TRACK TESTING PHASE I

TASK NUMBER	PROCEDURE	QA INITIAL
3.1	Perform testing as required by individual vehicle test plan.	

4.0 QUALITY VERIFICATION

TASK NUMBER	PROCEDURE	QA INITIAL
4.1	Quality verify that PKRG-3800-TC is complete and closed.	
4.2	Authorized QA signature ______________________________.	

INSTURM 2702 SIGNAL CONDITIONER SETUP PROCEDURE

I. <u>INTRODUCTION:</u> This procedure is provided as a supplement to the Manufacture Instruction Manual to organize information required in everyday use of the [illegible]2 amplifiers. This procedure should allow instrumentation personnel not familiar with this equipment to setup and operate the hardware and make minor configuration changes needed in normal operation.

This signal conditioning is very flexible and can be configured for many types of transducers.

This signal conditioning provides these features:

- **Excitation**-0 to 30 DC volts operating voltage
- **Amplification-** Gain to 12500 times transducer out
- **Filtering-** 4 pole Bessel elimination of undesired data
- **Common Mode Rejection**- 120dB. With up to 1000 ohms unbalance
- **Calibration-** Shunt or voltage insertion capability
- **Balancing-** Automatic and / or manual correction for input imbalance
- **Input Wiring**- Plug in configuration cards for up to 10 wire input wiring.

II. This document will concentrate on conditioning the most common type transducer now in use and will not attempt to replace the instruction manual and its theory of operation.

<u>SYSTEM CONFIGURATION</u>

The Instrum 2702 system is composed of a 10 channel mainframe cabinet and amplifier modules with a front panel plug-in containing input configuration cards. This configuration card selects the type of balancing, calibration and input wiring scheme for each transducer and will be discussed in more detail under each transducer type description

III. FRONT PANEL CONTROLS

The amplifier controls and test points required for normal operation are allocated on the front panel except for the main frame power switch and fuse on rear panel and output No. 2 filter switch inside the amplifiers right side cover. A brief description of the controls follows:

1. Gain Switch Located on bottom center of front panel and provides fixed gain steps of 1,2,5,10,20,50,100,200,500,1000,2000, and 5000.

2. Variable Gain Switch Allows multiplying the fixed gain switch setting up to 2.5 times. Use of this feature is indicated by a red LED on the lower left side of the instrument between the variable gain switch and variable gain screwdriver adjustment. (Use of variable gain is not recommended as a standard procedure.)

3. Filter Switch This switch near the bottom of the amplifier provides for selection of 15,30,120, or 360 hz. For internal forth order Bessel output filters. The fifth position is W.B. or wideband which bypasses any output filtering.

4. Output Monitor This pair of test points monitors output 1 and is used to set up signal conditioner.

5. Excitation Switch. This locking toggle switch provides for selection of 0-10, 10-20, and 20-30 volts DC and is located at the top of the front panel.

6. Level Control This screwdriver adjustment varies the excitation over the range selected by the excitation switch and is physically located right under the excitation switch.

7. Ex Test Points These pin jacks monitor the excitation set by the level control and are on the left side of the front panel near the middle.

8. In Monitor Points These pin jacks monitor the amplifier input after all signal conditioning such as balancing, input filtering or attenuation is complete. These points are on the left side of the front panel in the model 2059 plug-in.

9. Xd Monitor Points The pin jacks monitor the transducer output prior to any conditioning and are located on the left side of the model 2059 plug-in module.

10. Mode Select Switch This four position switch located in the model 2059 plug-in module is used to short amplifier input and to adjust offset controls, energizing calibration relays, selecting auto balance function or normal (data) mode. *Note* an extra, non-operational positon exists in the clockwise direction.

11. Bal/Bias Adjustment. This 10k potentiometer is used with R1 (user supplied) to provide manual control of the input balance (bias) voltage. This control might need adjustment to obtain proper auto balance range and fine balance.

12. Zero RTI Control. Provides mean of adjusting input stage DC offset when required. This adjustment is normally required after maintenance or repair.

13. Zero RTO Control This screwdriver adjustment is for control of the amplifier final stage offset, if required, and is located on the lower left front panel.

IV. USER SUPPLIED COMPONENTS

The model 2059 has provisions for soldering up to 10 resistors, capacitors or jumper wires to provide flexibility in input circuits. Specific purpose for each component will be listed under transducer type description. All components installed in these input circuits should be high quality, high stability parts to assure long term stable operation.

V. GENERAL OPERATING SEQUENCE

This section describes the normal procedures used for most measurement setups. Specific transducers are discussed in the following paragraphs.

1. Select transducer type and obtain calibration data.

2. Obtain proper configuration card and transducer input cable for selected transducer type.

185

3. Start data acquisition set-up form.

4. Install transducer using proper mounting technique for desired measurement.

5. Install transducer cable to proper amplifier input connector.

6. Install plug-in module after verifying voltage range selector on proper range and correct resistors are installed.

7. Turn on amplifier power.

8. Set desired excitation per calibration data manufactures data or test plan.

9. Place amplifier front panel control to short position and while monitoring output from front panel adjust RTO potentiometer to 0.000+/-.002 volts DC.

10. Set gain to fixed range determined from test requirements and calibration data.

11. Set front panel control to auto balance. A slow blinking green LED on front panel indicates proper balancing. If blinking becomes rapid, an input problem such as: improper configuration card, wrong transducer wiring, or a bad transducer is indicated correct this problem before proceeding. If auto balance span is too limited try auto balance at a lower gain and reset gain if good null obtained.

12. After autobalance is achieved, as indicated by steady green LED, switch to data position and verify satisfactory balance. Bal/bias adjustment will allow fine setting if required.

13. Switch to Cal position and record calibration output voltage on data acquisition form.

14. Return front panel switch to data position.

VI. FULL BRIDGE MEASUREMENTS

To use the 2702 with 4 leg or full bridge input transducers such as strain gage circuits, install an Instrum type "H" configuration card in the 2059 plug-in. Typical values for the plug-in and there functions are listed below:

R1	100k ohms	Balance Limit
R2	Short	Input filter
C1	Open	Input filter
R3	Short	Input filter
R4	Open	Not Used
R5	Open	Not Used
R6	100k ohms	Auto Balance Limit
R7	Open	Not Used
R8	xxx.ohms	Shunt Calibration
R9	Open	Not Used

The value of R8 to be determined from the transducer calibration data or from the following equations:

$$Es = \frac{Rg x 10^{(-6)}}{K x (Rsh + Rg)}$$

$$Eo = \frac{E1 \times K \times Es}{4}$$

Where
Rsh = R8 = ohms
Rg = Gage = ohms
Es = Simulated strain
K = Gage factor
Eo = Bridge volts output
E1 = Excitation volts

In setting up the signal conditioning, excitation should be determined from the manufacturer's power dissipation data for that type of measurement. The general rule is to use the highest excitation that gives the required stability, but never exceed the manufacture's safe excitation level.

VII. LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT)

The signal conditioners are set up to provide excitation isolation and gain for DC powered LVDT's by installing a type "K" Instrum configuration card in the 2059 plug-in. Have these transducers set up for voltage substitution calibration and auto balancing. Typical values for user installed components are listed below:

R1	10k ohms	Main Balance Span
R2,R3	Short	Input Filter
C1	Open	Input Filter
R4	Open	Not Used
*R5	5k ohms	Balance Range
R6	10k ohms	Auto Balance Limit
R7	20k ohms	Voltage Sub Divider
R8	1-20k ohms	Voltage Sub Divider
R9	Short	

* Should be 1 to 10k using lowest value needed to obtain balance span desired.
Voltage sub can be calculated using the following equation.

$$\text{Vsub} = \frac{\text{R8} \times 10}{\text{R7} + \text{R8}}$$

VIII. SETRA 141A ACCELEROMETERS

With the type "J" Instrum configuration card installed in the model 2059 plug-in, and with proper selection of the user installed components, the 2702 will provide excitation, auto balancing (+/- 1g input), gain, filtering and shunt calibration. The nominal values of user supplied components are as listed below for subject accelerometers.

R1, R6	20-100k ohms	Balance Limiting
R5	2k ohms	Balance Span
R2,R3	Short	Input Filter
C1	Open	Input Filter
R8	100k ohms	*see note
R9	1n4746A	Over-voltage Protection

NOTE 100k across calibration lead will provide approximately .1 volt output. Actual voltage for each installed accelerometer should be accurately measured at the input and also referring to the calibration data determine the equivalent "g" reading. This resistor value can be raised to simulate less output or lowered to produce more signal.

Prior to installing the plug-in in the amplifier, verify the excitation range switch is in the 0-10 volt position. Adjust excitation to 10.0 volts and verify desired gain setting (50 or less). Switch selector to auto balance while monitoring output. Balance will be obtained in about 45 seconds. If the green LED blinks rapidly corrective action is required. After balance is obtained set switch to data or cal position. Never leave in Auto position after switching from any other position or a new balance will be obtained. Any time auto balance is terminated prior to completion, the old balance setting is restored. In this configuration, the calibration output is added to the transducer output. Therefore if there is .02 volt unbalance or signal caused be grade or superelevation etc, the output will be equal to the cal voltage plus offset or .02 + .1 or .12 VDC.

IX. POTENTIOMETER SERO ACCELEROMETER AND VOLTAGE INPUT CONFIGURATION

This configuration card (type "K") is the same used for the DC/DC LVDT's (section VII) but uses slight changes to the plug-in card components. The main difference in using it for voltage inputs is to eliminate the wiring input cabling to provide excitation. This card, however, is designed to excite and accept inputs from almost any DC powered transducer. Typical use for voltage input would be to buffer (isolate) signals from other systems. Typical values for the user installed components and there functions are listed below.

R1,R6	50-100k ohms	Balance Range
R2,R3	Short	Input Filter
C1	Open	Input Filter
R4	Open	Input Attenuation
R5	1-10k ohm	Balance Current
R7	10k minimum	Voltage Substitution

R8	1 10k ohm	Volt Sub Divider
R9	Short	Input Attenuation

*Use lowest value needed to obtain desired balance span.

Voltage substitution (Vsub) can be calculated using the formula:

$$\text{Vsub} = \frac{\text{R8} \times 10}{\text{R7} + \text{R8}}$$

X. AMPLIFIER ZERO AND INITIAL SETUP

This section defines checking and adjusting the amplifier zero:

1. Set front panel control to short position.
2. Set gain to 1000 (fixed) and note output No. 1 Voltage.
3. Switch to gain = 1 and note output.
4. Adjust RTI control so that step 2 output = step 3 output.
5. Repeat steps 2,3 and 4 until output is constant.
6. Adjust output with RTO control for 0.000 +/- 1 mv Dc.
7. If second output is being used and a offset is noted, refer to instruction manual for bench instruction procedure.

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 1 OF 10

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE 9-11-90 W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO.
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO.
SET-UP FILE MIF_TRIP04

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO	EXC.- L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ	GAIN	CAL VOID DATE	AO (E.U.)	AI (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV.)	
ALD	0	0	XOX 001A	VARNER		20 ms PULSE	X= Y= Z=												0	1 EVENT 10V	EVENT	16		ALD
TSPD	1	1	ROW 001D	AIR PAX		64 PULSE/REV	X= Y= Z=												0	10 MPH/V	MPH	8		SPEED
FVIL	2	2	LBV 001A	IITRI	19 A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	1		36' IWS VERT RT CAR-1 LEAD AXLE TRK-3
FVIR	3	3	LBV 002A	IITRI	19 B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	2		36' IWS VERT LF CAR-1 LEAD AXLE TRK-3
FLIL	4	4	LBV 003A	IITRI	19 A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	3		36' IWS LAT RT CAR-1 LEAD AXLE TRK-3
FLIR	5	5	LBV 004A	IITRI	19 B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	4		36' IWS LAT LF CAR-1 LEAD AXLE TRK-3
LVIL	6	6	LBV 005A	IITRI	19 A	CALC	X= Y= Z=									15 Hz	1		0	.5 KIPS/V	KIPS	5		36' IWS L/V RT CAR-1 LEAD AXLE TRK-3
LVIR	7	7	LBV 006A	IITRI	19 B	CALC	X= Y= Z=									15 Hz	1		0	.5 KIPS/V	KIPS	6		36' IWS L/V LF CAR-1 LEAD AXLE TRK-3
FT1	8	8	LBV 007A	IITRI	19	CALC	X= Y= Z=									15 Hz	1		0	3.4 KIPS/V	KIPS	7		36' IWS TORQUE CAR-1 LEAD AXLE TRK-3
FV2L	9	9	LBV 008A	IITRI	17 A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	9		38' IWS VERT RT CAR-2 LEAD AXLE TRK-1

NOTES:

ACAD FILE: TRIP101.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 2 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________ MIF_TRIP04

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ.	GAIN	CAL VOID DATE	A0 (E.U.)	A1 (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS (E.U./DIV.)	
FV2R	10		LBW 009A	IITRI	17B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	10		38' IWS VERT LF CAR-2 LEAD AXLE TRK-1
FL2R	11		LBW 010A	IITRI	17A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	11		38' IWS LAT RT CAR-2 LEAD AXLE TRK-1
FL2R	12		LBW 011A	IITRI	17B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	12		38' IWS LAT LF CAR-2 LEAD AXLE TRK-1
LV2L	13		LBW 012A	IITRI	17A	CALC	X= Y= Z=									15 Hz	1		0	.5 L/V /V	KIPS	13		38' IWS L/V RT CAR-2 LEAD AXLE TRK-1
LV2R	14		LBW 013A	IITRI	17B	CALC	X= Y= Z=									15 Hz	1		0	.5 L/V /V	KIPS	14		38' IWS L/V LF CAR-2 LEAD AXLE TRK-1
FT2	15		LBW 014A	IITRI	17	CALC	X= Y= Z=									15 Hz	1		0	6.67 KIPS/V	KIPS	15		38' IWS TORQUE CAR-2 LEAD AXLE TRK-1
FV3L	16		LBW 015A	ENSCO	1A	CALC	X= Y= Z=									15 Hz	1		0	7.5 KIPS/V	KIPS	17		38' IWS VERT RT CAR-2 LEAD AXLE TRK-2
FV3R	17		LBW 016A	ENSCO	1B	CALC	X= Y= Z=									15 Hz	1		0	7.5 KIPS/V	KIPS	18		38' IWS VERT LF CAR-2 LEAD AXLE TRK-2
FL3L	18		LBW 017A	ENSCO	1A	CALC	X= Y= Z=									15 Hz	1		0	6 KIPS/V	KIPS	19		38' IWS LAT RT CAR-2 LEAD AXLE TRK-2
FL3R	19		LBW 018A	ENSCO	1B	CALC	X= Y= Z=									15 Hz	1		0	6 KIPS/V	KIPS	20		38' IWS LAT LF CAR-2 LEAD AXLE TRK-2

NOTES:

ACAD FILE: TRIP102 DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 3 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF TRIP04
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER MFG.	TRANSDUCER S.N.	TRANSDUCER SENS.	TRANSDUCER LOC.	TRANSDUCER CAL VOID DATE	AMPLIFIER CH. NO.	AMPLIFIER EXC.- L/R	AMPLIFIER GAIN FIX/VAR	AMPLIFIER R-CAL RES.	AMPLIFIER CAL. E.U. & VOLTS	AMPLIFIER S.N. CAL VOID DATE	FILTER NO.	FILTER FREQ	FILTER GAIN	FILTER CAL VOID DATE	SYSTEM A0 (E.U.)	SYSTEM A1 (E.U./VOLT)	SYSTEM ENGR. UNITS	RECORDER CH. NO.	RECORDER SENS. (E.U./DIV.)	COMMENTS
LV3L	20	20	LBV 019A	ENSCO	1A	CALC	X= Y= Z=									15 Hz	1		0	.25 L/V /V	L/V	21		38' IWS L/V RT CAR-2 LEAD AXLE TRK 2
LV3R	21	21	LBV 020A	ENSCO	1B	CALC	X= Y= Z=									15 Hz	1		0	.25 L/V /V	L/V	22		38' IWS L/V LF CAR-2 LEAD AXLE TRK 2
FT3	22	22	LBV 021A	ENSCO	1	CALC	X= Y= Z=									15 Hz	1		0	2 KIPS/V	KIPS	23		38' IWS TORQUE CAR-2 LEAD AXLE TRK 2
FV4L	23	23	LBV 022A	IITRI	18A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	25		38' IWS VERT RT CAR-2 LEAD AXLE TRK 3
FV4R	24	24	LBV 023A	IITRI	18B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	26		38' IWS VERT LF CAR-2 LEAD AXLE TRK 3
FL4L	25	25	LBV 024A	IITRI	18A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	27		38' IWS LAT RT CAR-2 LEAD AXLE TRK 3
FL4R	26	26	LBV 025A	IITRI	18B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	28		38' IWS LAT LF CAR-2 LEAD AXLE TRK 3
LV4L	27	27	LBV 026A	IITRI	18A	CALC	X= Y= Z=									15 Hz	1		0	.5 L/V/V	L/V	29		38' IWS L/V RT CAR-2 LEAD AXLE TRK 3
LV4R	28	28	LBV 027A	IITRI	18B	CALC	X= Y= Z=									15 Hz	1		0	.5 L/V/V	L/V	30		38' IWS L/V LF CAR-2 LEAD AXLE TRK 3
FT4	29	29	LBV 028A	IITRI	18	CALC	X= Y= Z=									15 Hz	1		0	6.67 KIPS/V	KIPS	31		38' IWS TORQUE CAR-2 LEAD AXLE TRK 3

NOTES:

ACAD FILE: TRIP103.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 4 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF TRIP04
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ	GAIN	CAL VOID DATE	A0 (E.U.)	A1 (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV)	
FV5L	30	30	LBW 029A	ENSCO	2A	CALC	X= Y= Z=									15 Hz	1		0	7.5 KIPS/V	KIPS	33		38' IWS VERT RT CAR-2 LEAD AXLE TRK-4
FV5R	31	31	LBW 030A	ENSCO	2B	CALC	X= Y= Z=									15 Hz	1		0	7.5 KIPS/V	KIPS	34		38' IWS VERT LF CAR-2 LEAD AXLE TRK-4
FL5L	32	32	LBW 031A	ENSCO	2A	CALC	X= Y= Z=									15 Hz	1		0	6 KIPS/V	KIPS	35		38' IWS LAT RT CAR-2 LEAD AXLE TRK-4
FL5R	33	33	LBW 032A	ENSCO	2B	CALC	X= Y= Z=									15 Hz	1		0	6 KIPS/V	KIPS	36		38' IWS LAT LF CAR-2 LEAD AXLE TRK-4
LV5L	34	34	LBW 033A	ENSCO	2A	CALC	X= Y= Z=									15 Hz	1		0	.25 L/V /V	L/V	37		38' IWS L/V RT CAR-2 LEAD AXLE TRK-4
LV5R	35	35	LBW 034A	ENSCO	2B	CALC	X= Y= Z=									15 Hz	1		0	.25 L/V /V	L/V	38		38' IWS L/V LF CAR-2 LEAD AXLE TRK-4
FT5	36	36	LBW 035A	ENSCO	2	CALC	X= Y= Z=									15 Hz	1		0	2 KIPS/V	KIPS	39		38' IWS TORQUE CAR-2 LEAD AXLE TRK-4
FV6L	37	37	LBW 036A	IITRI	20A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	41		36' IWS VERT RT CAR-3 LEAD AXLE TRK-1
FV6R	38	38	LBW 037A	IITRI	20B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	42		36' IWS VERT LF CAR-3 LEAD AXLE TRK-1
FL6L	39	39	LBW 038A	IITRI	20A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	43		36' IWS LAT RT CAR-3 LEAD AXLE TRK-1

NOTES:

ACAD FILE: TRIP104.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 5 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF_TRIP04
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ	GAIN	CAL VOID DATE	AO (E.U.)	AI (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV.)	
FL6R	40		LBV 039A	IITRI	20B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	44		36' IWS LAT LF CAR-3 LEAD AXLE TRK-1
LV6L	41		LBV 040A	IITRI	20A	CALC	X= Y= Z=									15 Hz	1		0	0.5 L/V /V	L/V	45		36' IWS L/V RT CAR-3 LEAD AXLE TRK-1
LV6R	42		LBV 041A	IITRI	20B	CALC	X= Y= Z=									15 Hz	1		0	0.5 L/V /V	L/V	46		36' IWS L/V LF CAR-3 LEAD AXLE TRK-1
FT6	43		LBV 042A	IITRI	20	CALC	X= Y= Z=									15 Hz	1		0	3.4 KIPS/V	KIPS	47		36' IWS TORQUE CAR-3 LEAD AXLE TRK-1
SP1	44						X= Y= Z=																	SPARE
JBX1	45		JBX 001A	HUMPHREY	105	3.951 DEG/V	X= Y= Z=	9-2-90	K	10 V	1 FIX	VSUB				15 Hz				0.988 DEG/V	DEG			CAR BODY ROLL ANGLE A-END CAR-1
AZ1	46		AZ1L	ENDEVCO 7290	AC 55	198.7 MV/G	X= Y= Z=	10-9-90	K	15 V	2 FIX	VSUB	3.342 V			120 Hz				2.516 G/V	G			ACCEL VERT CAR-1 ABOVE SPAN BLST 1
AZ2	47		AZ2L	ENDEVCO 7290	AC 99	197.9 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.320 V			120 Hz				2.527 G/V	G			ACCEL VERT CAR-1 CAR CTR FLOOR
AZ3	48		AZ3L	ENDEVCO 7290	AD 66	205.1 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.328 V			15 Hz				2.438 G/V	G			ACCEL VERT CAR-1 ABOVE SPAN BLST 2
AY1	49		AY1L	ENDEVCO 7290	AK 33	199.6 MV/G	X= Y= Z=	10-9-90	K	15 V	2 FIX	VSUB	3.332 V			120 Hz				2.505 G/V	G			ACCEL LAT CAR-1 ABOVE SPAN BLST 1

NOTES:

ACAD FILE: TRIP105.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 6 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS

INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________

SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF TRIP04

SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES.	CAL E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ	GAIN	CAL VOID DATE	A0 (E.U.)	A1 (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS (E.U./DIV.)	
AY2	50	50	AY2L	ENDEVCO 7290	AD 83	196.6 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.323 V			120 Hz	1			2.543 G/V	G			ACCEL CAR-1 LAT CTR FLOOR
AY3	51	51	AY3L	ENDEVCO 7290	AE 27	197.4 MV/G	X= Y= Z=	10-9-90	K	15 V	2 FIX	VSUB	3.326 V			15 Hz				2.533 G/V	G			ACCEL CAR-1 LAT ABOVE SPAN BLST 2
AX1	52	52	AX1L	ENDEVCO 7290	AE 35	201.2 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.321 V			15 Hz				2.485 G/V	G			ACCEL CAR-1 LONG ABOVE SPAN BLST 1
AX2	53	53	AX2L	ENDEVCO 7290	AE 36	198.5 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.317 V			15 Hz				2.519 G/V	G			ACCEL CAR-1 LONG ABOVE SPAN BLST 2
SP2	54	54					X= Y= Z=																	SPARE
JBX2	55	55	JBX 002A	HUMPHREY	103	4.000 DEG/V	X= Y= Z=	9-2-90	K	10 V	1 FIX	VSUB				15 Hz	1			1.000 DEG/V	DEG			A-END CAR-2 CARBODY ROLL ANGLE
DBX1	56	56	DBX 001A	CELESCO	A 45654	0.4724 V/IN	X= Y= Z=	8-3-91	K	10 V	1 FIX	VSUB				15 Hz	1			2.117 IN/V	INCHS			A-END CAR-2 COUPLER ANGLE LF
DBX2	57	57	DBX 002A	CELESCO	A 46550	0.4730 V/IN	X= Y= Z=	8-3-91	K	10 V	1 FIX	VSUB				15 Hz	1			2.114 IN/V	INCHS			A-END CAR-2 COUPLER ANGLE RT
IC1	58	58	IC LC1	DYNO-COUPLER	25		X= Y= Z=	2-3-91	H1	5 V	VAR	174.6 K	111.76 KIPS 5.58 V			15 Hz	1			20 KIPS/V	KIPS			A-END CAR-2 INSTRUMENTED COUPLER
LTV1	59	59	LTHD V1				X= Y= Z=														G			LTHD VERT TRK-1 CAR-2

NOTES:

ACAD FILE: TRIP106.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 7 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF_TRIP04
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ.	GAIN	CAL VOID DATE	A0 (E.U.)	A1 (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV.)	
LTV2	60	60	LTHD V2				X= Y= Z=														G			CAR-2 LTHD VERT TRK-1
LTL1	61	61	LTHDL1				X= Y= Z=														G			CAR-2 LTHD LAT TRK-1
AZ4	62	62	AZ4C	ENDEVCO 7290	AE 37	198.1 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.320 V			120 Hz	1			2.524 G/V	G			CAR-2 ACCEL-VERT ABOVE SPAN BLST 1
AY4	63	63	AY4C	ENDEVCO 7290	AC 57	199.1 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.327 V			120 Hz	1			2.511 G/V	G			CAR-2 ACCEL LAT ABOVE SPAN BLST 1
AX3	64	64	AX3C	ENDEVCO 7290	AE 38	198.7 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.323 V			120 Hz	1			2.516 G/V	G			CAR-2 ACCEL LONG ABOVE SPAN BLST 1
JBX3	65	65	JBX 003A	HUMPREY	107	4.071 DEG/V	X= Y= Z=	9-5-90	K	10 V	1 FIX	VSUB				15 Hz	1			1.018 DEG/V	DEG			CAR-2 B-END CARBODY ROLL ANGLE
DBX3	66	66	DBX 003A	CELESCO	A 45651	0.4721 V/IN	X= Y= Z=	4-23-91	K	10 V	1 FIX	VSUB				15 Hz	1			2.118 IN/V	INCH			CAR-2 COUPLER ANGLE B-END LF
DBX4	67	67	DBX 004A	CELESCO	A 45653	0.4733 V/IN	X= Y= Z=	5-30-91	K	10 V	1 FIX	VSUB				15 Hz	1			2.113 IN/V	INCH			CAR-2 COUPLER ANGLE B-END RT
IC2	68	68	IC TC2	BLH	20999		X= Y= Z=	10-4-90	H1	10 V	VAR	59.88 K	96.7 KIPS 4.834 VDC			15 Hz	1			20 KIPS/V	KIPS			CAR-2 B-END INSTRUMENTED COUPLER
AZ5	69	69	AZ5C	ENDEVCO 7290	AE 42	198.1 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.315 V			120 Hz	1			2.524 G/V	G			CAR-2 CTR FLOOR ACCEL VERT CAR

NOTES:

ACAD FILE: TRIP107.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 8 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF TRIP04
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC. L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ.	GAIN	CAL VOID DATE	A0 (E.U.)	A1 (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV.)	
AZ6	70	70	AZ6C	ENDEVCO 7290	AE 48	208.2 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.339 V			120 Hz	1			2.402 G/V	G			ACCEL VERT ABOVE SPAN BLST 2 CAR-2
AY5	71	71	AY5C	ENDEVCO 7290	AE 49	199.6 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.334 V			120 Hz	1			2.505 G/V	G			ACCEL LAT CAR CTR FLOOR CAR-2
AY6	72	72	AY6C	ENDEVCO 7290	AC 97	203.2 MV/G	X= Y= Z=	11-6-90	K	15 V	2 FIX	VSUB	3.331 V			120 Hz	1			2.461 G/V	G			ACCEL LAT ABOVE SPAN BOLSTER 2 CAR-2
AX4	73	73	AX4C	ENDEVCO 7290	AE 50	196.3 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.340 V			15 Hz	1			2.547 G/V	G			ACCEL LONG ABOVE SPAN BLST 2 CAR-2
DBX5	74	74	DBX5	CELESCO	A 45611		X= Y= Z=	3-7-91	K	10 V	1 FIX	VSUB				15 HZ				.802 IN/V	IN			DISPLACEMENT SPAN BLST-1 TO CARBODY CAR-2 A-END
JBX4	75	75	JBX 004A	HUMPHREY	101	3.819 DEG/V	X= Y= Z=	9-5-90	K	10 V	1 FIX	VSUB				15 Hz	1			0.955 DEG/V	DEG			CARBODY ROLL ANGLE B-END CAR-3
AZ7	76	76	AZ7E	ENDEVCO 7290	AE 51	198.9 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.330 V			15 Hz	1			2.514 G/V	G			ACCEL VERT ABOVE SPAN BLST 1 CAR-3
AZ8	77	77	AZ8E	ENDEVCO 7290	AE 54	197.8 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.333 V			15 Hz	1			2.528 G/V	G			ACCEL VERT ABOVE SPAN BLST 2 CAR-3
AY7	78	78	AY7E	ENDEVCO 7290	AE 58	197.8 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.322 V			15 Hz	1			2.528 G/V	G			ACCEL LAT ABOVE SPAN BLST 1 CAR-3
AY8	79	79	AY8E	ENDEVCO 7290	AE 71	198.8 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.339 V			15 Hz	1			2.515 G/V	G			ACCEL LAT ABOVE SPAN BLST 2 CAR-3

NOTES:

ACAD FILE: TRIP108.DWG.

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 9 OF

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO.
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO.
SET-UP FILE MIF TRIP04

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH NO	EXC.-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO	FREQ	GAIN	CAL VOID DATE	AO (E.U.)	AI (E.U./VOLT)	ENGR. UNITS	CH NO	SENS. (E.U./DIV.)	
AX5	80	80	AX5E	ENDEVCO 7290	AE 66	200.0 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.325 V			15 Hz	1			2.500 G/V	G			ACCEL LONG ABOVE SPAN BLST 1 CAR-3
AX6	81	81	AX6E	ENDEVCO 7290	AE 70	201.3 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.334 V			15 Hz	1			2.484 G/V	G			ACCEL LONG ABOVE SPAN BLST 2 CAR-3
SP4	82	82					X= Y= Z=																	SPARE
IRIG	83	83	IRIG-B				X= Y= Z=																	IRIG-B DIGITAL INTERFACE
V19A	84	84	V19AA	IITRI	19A		X= Y= Z=			15	1000	681 K	1.980 V			200	1							IWS CAR-1 TRK-3 LEAD AXLE RT VERT A
V19B	85	85	V19AB	IITRI	19A		X= Y= Z=			15	1000	681 K	1.980 V			200	1							IWS CAR-1 TRK-3 LEAD AXLE RT VERT B
V19C	86	86	V19AC	IITRI	19A		X= Y= Z=			15	1000	681 K	1.980 V			200	1							IWS CAR-1 TRK-3 LEAD AXLE RT VERT C
L19A	87	87	L19AA	IITRI	19A		X= Y= Z=			15	1000	118 K	1.535 V			200	1							IWS CAR-1 TRK-3 LEAD AXLE RT LAT A
L19B	88	88	L19AB	IITRI	19A		X= Y= Z=			15	1000	118 K	1.535 V			200	1							IWS CAR-1 TRK-3 LEAD AXLE RT LAT B
VA19	89	89	V19BA	IITRI	19B		X= Y= Z=			15	1000	681 K	1.980 V			200	1							IWS CAR-1 TRK-3 LEAD AXLE LF VERT A

NOTES:

ACAD FILE: TRIP109.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 10 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE I DATE ______ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ______
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ______ SET-UP FILE MIF TRIP04
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ______

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO	FREQ	GAIN	CAL VOID DATE	AO (EU)	AI (EU/VOLT)	ENGR. UNITS	CH. NO.	SENS. (EU/DIV)	
VB19	90	90	V19BB	IITRI	19B		X= Y= Z=			15	1000	681 K	1.980 V			200 Hz	1							IWS CAR-1 TRK-3 LEAD AXLE RT VERT B
VC19	91	91	V19BC	IITRI	19B		X= Y= Z=			15	1000	681 K	1.980 V			200 Hz	1							IWS CAR-1 TRK-3 LEAD AXLE RT VERT C
LA19	92	92	L19BA	IITRI	19B		X= Y= Z=			15	200	118 K	1.535 V			200 Hz	1							IWS CAR-1 TRK-3 LEAD AXLE RT LAT A
LB19	93	93	L19BB	IITRI	19B		X= Y= Z=			15	200	118 K	1.535 V			200 Hz	1							IWS CAR-1 TRK-3 LEAD AXLE RT LAT B
P19A	94	94	P19AA	IITRI	19A		X= Y= Z=			15	1000	815 K	1.095 V			200 Hz	1							IWS CAR-1 TRK-3 LEAD AXLE RT POSITION
P19B	95	95	P19BA	IITRI	19B		X= Y= Z=			15	1000	815 K	1.095 V			200 Hz	1							IWS CAR-1 TRK-3 LEAD AXLE LF POSITION
V17A	96	96	V17AA	IITRI	17A		X= Y= Z=			25	1000	1000 K	2.259 V			200 Hz	1							IWS CAR-2 TRK-1 LEAD AXLE RT VERT A
V17B	97	97	V17AB	IITRI	17A		X= Y= Z=			25	1000	1000 K	2.259 V			200 Hz	1							IWS CAR-2 TRK-1 LEAD AXLE RT VERT B
V17C	98	98	V17AC	IITRI	17A		X= Y= Z=			25	1000	1000 K	2.259 V			200 Hz	1							IWS CAR-2 TRK-1 LEAD AXLE RT VERT C
L17A	99	99	L17AA	IITRI	17A		X= Y= Z=			20	1000	511 K	2.374 V			200 Hz	1							IWS CAR-2 TRK-1 LEAD AXLE RT LAT A

NOTES:

ACAD FILE: TRIP10.DWG

(3)

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-9000-TC
ON-TRACK TEST PHASE II

201

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-9000-TC
ON-TRACK TEST PHASE II

1.0 DESCRIPTION

This procedure outlines the sequence of steps to conduct the On-Track Phase II Test at the Transportation Test Center (TTC). The on-track testing consist of seven sub-tests:

1. Hunting Test
2. Constant Curving Test
3. Spiral Negotiation Test
4. Rock and Roll Test
5. Pitch and Bounce Test
6. Yaw and Sway Test
7. Dynamic Curving

One additional test, the Wayside Measurements, has been added for the Rail Garrison program.

1.1 INDEX

1.2 EQUIPMENT LIST

a.	4ea.	IITRI Instrumented Wheel Sets
b.	2ea.	ENSCO Instrumented Wheel Sets
c.	2ea.	Single Roll Gyrometer
d.	2ea.	Lateral Accelerometer
e.	6ea.	Strip Chart Recorder
f.	1ea.	Digitizer
g.	4ea.	100-Ton Jacks
h.	1ea.	HP 360 Data Acquisition System
i.	160ea.	Signal Conditioner
j.	4ea.	Video Cameras
k.	As needed	Wayside Measurements and Angle of Attack
l.		All Safety Equipment as Required by TTC

1.3 FIGURE LIST

1.4 TABLE LIST

1.5 REFERENCE LIST

PRKG 2200....	Car Inspection Procedure
PKRG 3100....	Instrument Installation Procedure
PKRG 3300.....	ENSCO 38" Instrumented Wheel Sets Installation, Calibration and Operation
PKRG 3400.....	IITRI 38" Instrumented Wheel Sets Installation, Calibration and Operation
PKRG 3500.....	IITRI 36" Instrumented Wheel Sets Installation Calibration and Operation
PKRG 3900-TC	On-track Test Phase II Test Setup
PKRG 7001.....	Test Sequence Chart
PKRG 7002.....	Daily Pre-test Sign-off Sheet
PKRG 8100.....	Loading/Unloading Procedure for 36" Triplet Cars

M1001........ Manual of Standards and Recommended Practices, Section C, Part II, Volume I, Chapter XI

Peacekeeper Rail Garrison Test Implementation Plan, (for appropriate test car), Chapter XI Testing

TTC Operation Rules for the Transportation Test Center, Pueblo, Colorado, AAR, November 1, 1989

ENSCO Operating Manual

IITRI Operating Manual

TTC Safety Rule Book

1.6 TEST DOCUMENTATION LIST

None

NOTE

All personnel involved in the performance of this procedure or observing the test(s) will comply with the TTC Safety Rule Book.

2.0 PRE-TEST SETUP FOR ALL TESTS (EXCEPT YAW AND SWAY)

2.1 38" Instrumented Wheel Set Installation on MLC

TASK NUMBER	PROCEDURE	QA INITIAL
2.1.1	Chock all B-end wheels.	
2.1.2	Disconnect the hand brake chain and air brake line.	
2.1.3	Ensure brake shoes and keys are removed from each instrumented wheel location.	______
2.1.4	Remove all slack adjusters.	______
2.1.5	Secure emergency brake chain.	
2.1.6	Mark the removed components defining location from which they were removed and store components for later reinstallation.	
2.1.7	Using two 100-ton jacks at the jacking pad, jack the test car up approximately 12 inches to remove the A-end running gear assembly.	
2.1.8	Roll the span bolster and trucks away from the car.	
2.1.9	Lift the front of the span bolster and place on blocks.	

2.1.10 Roll out Truck 4.

2.1.11 Lift Truck 4 and remove the leading Axle 7 wheel set.

2.1.12 Replace the leading wheel set with the IITRI WS 17 Instrumented Wheel Set. Place wheel A on the left side of car. ________

2.1.13 Roll the truck back under the span bolster.

2.1.14 Lower the span bolster.

2.1.15 Lift the rear of the span bolster and place on blocks.

2.1.16 Roll out Truck 3.

2.1.17 Lift Truck 3 and remove wheel set (Axle 5).

2.1.18 Replace the leading wheel set with the ENSCO WS 1 Instrumented Wheel Set. Place wheel A on the left side of car. ________

2.1.19 Roll the truck back under the span bolster.

2.1.20 Lower the span bolster and replace the running gear assembly.

2.1.21 Lower the jacks.

2.1.22 Repeat Steps 2.1.1 through 2.1.21 for the B-end running gear assembly using IITRI WS 18 under Truck 2 (Axle 3) and ENSCO WS 2 under Truck 1 (Axle 1).

2.1.23 Quality verify the completion of the wheel set change out. ______

2.2 36" Instrumented Wheel Set Installation on MLC

TASK NUMBER	PROCEDURE	QA INITIAL
2.2.1	Chock all A-end wheels.	
2.2.2	Disconnect the hand break chain and air brake line on the lead Triplet Car.	
2.2.3	Ensure brake shoes and keys are removed from each instrumented wheel location.	______
2.2.4	Remove all slack adjusters.	
2.2.5	Secure emergency brake chain.	
2.2.6	Mark the removed components defining location in which they were removed and store components for later installation.	
2.2.7	Using two 100-ton jacks at the jacking pad, jack the test car up approximately 12 inches to remove the B-end running gear assembly.	
2.2.8	Roll the span bolster and trucks away from the car.	
2.2.9	Lift the front of the span bolster and place on blocks.	
2.2.10	Roll out Truck 2.	

2.2.11 Lift Truck 2 and remove the leading Axle 4 wheel set.

2.2.12 Replace the leading wheel set with the 36" IITRI Instrumented Wheel Set. Place wheel A on left side of car.

2.2.13 Roll the truck back under the span bolster.

2.2.14 Lower the span bolster and replace the running gear assembly.

2.2.15 Lower jacks.

2.2.16 Quality verify the completion of the wheel set change out as shown in Figure 2-1.

2.2.17 Repeat all 36" Instrumented Wheel Set Installation Procedures for next 36" Wheel Set Triplet Car, replacing Truck 4 (Axle 8) with the IITRI 36" Instrumented Wheel Set.

2.2.18 Quality verify the completion of the wheel set change out as shown in Figure 2-1.

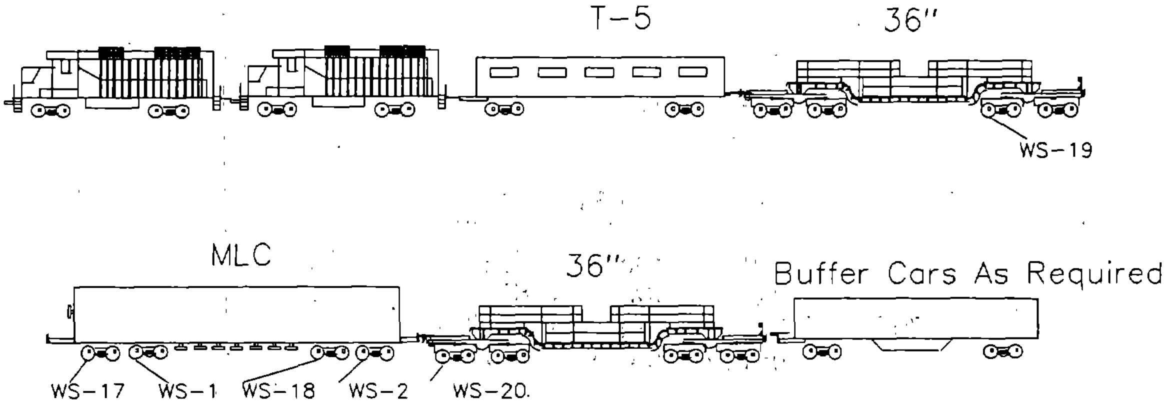

Figure 2-1 Triplet and MLC Instrumented Wheel Set Configuration

2.3 Coupling of the Test Car and the Instrumentation Car

TASK NUMBER	PROCEDURE	QA INITIAL
	CAUTION **Restrict coupling speed to 3.5 mph**	
2.3.1	Couple the A-end of the loaded 36-inch Triplet Car to the T-5. Couple the B-end of the fully loaded MLC to the lead Triplet Car and couple the A-end of the trailing loaded 36-inch Triplet Car to the MLC. Couple loaded 100-ton buffer cars to the test cars as required for braking. The number of buffer cars may be changed due to braking needs and stability of the buffer cars, as determined during testing. Couple all cars as shown in Figure 2-2.	______

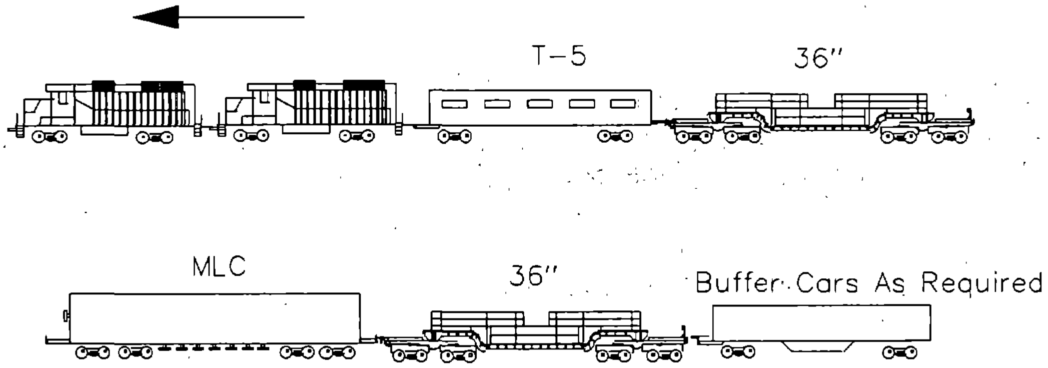

Figure 2-2 Core Test Consist

2.4 38" Instrumentation Checkout and Setup

TASK NUMBER	PROCEDURE	QA INITIAL
2.4.1	Calibrate instrumentation in accordance with PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3900-TC On-track Test Phase II Test Setup.	______

2.5 36" Instrumentation Checkout and Setup

TASK NUMBER	PROCEDURE	QA INITIAL
2.5.1	Calibrate instrumentation in accordance with PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3900-TC On-track Test Phase II Test Setup.	______

NOTE

Test sequence is arbitrary. The test sequence may be dictated by track availability at TTC.

3.0 LATERAL STABILITY ON TANGENT TRACK (HUNTING)

3.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
3.1.1	Ensure that buffer cars are coupled to the core test consist as illustrated in Figure 2-2.	______
3.1.2	Ensure that instrumentation meets the requirements outlined in PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation, and PKRG-3900-TC On-track Test Phase II Test Setup.	______
3.1.3	Ensure that instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation, and PKRG-3900-TC On-track Test Phase II Test Setup.	______

211

3.2 On-track Test

TASK NUMBER **PROCEDURE** **QA INITIAL**

NOTE

Test to be conducted on 5,000 foot of dry tangent track on the RTT with Class 5 or better track (R39-R33).

CAUTION

Stop testing when lateral acceleration exceeds 1.0 g peak to peak or any maximum axle sum L/V exceeds 1.3 for 50 millisecond.

3.2.1.1 Ensure applicable perturbations have been verified. ______

3.2.1.2 Ensure pre-test sign off sheet PKRG-7002 has been completed. ______

3.2.2 During the initial 30 mph +/- 1 mph track conditioning run, keep the speed constant through the test zone.

3.2.3 Start acquiring lateral acceleration data 200 - 300 ft. before reaching the test zone. The computer should be triggered by Automatic Location Device (ALD).

3.2.4 Stop data acquisition 200 - 300 ft. beyond the test zone.

3.2.4.1 Review test, ensure data is acceptable and indicates that the test can be continued. ______

3.2.5 Increase speed in increments of 10 mph, +/- 1 mph, with each test run, until approaching a critical point (80 percent of stop criteria) (0.8 g peak to peak, 1.0 L/V); then, increase speed in increments of 2 mph until a maximum test speed of 70 mph is reached. ______

3.2.6 In the Test Engineer's Log, note the speed at which the car sustains truck hunting, if hunting occurs. (Per Chapter XI criteria 1.0 g peak to peak for 20 seconds). ______

3.2.7 Quality verify that the test is completed. ______

3.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
3.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3900-TC.	______
3.3.2	Carman perform Post Test Visual Inspection of train.	______

NOTE

If defects are found, record on PKRG-2200.

4.0 CONSTANT CURVING TEST

4.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
4.1.1	Instrumentation for this test should be as per Section 2.0.	
4.1.2	Ensure that instrumentation meets the requirements outlined in PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3900-TC On-track Test Phase II Test Setup.	______

4.1.3 Ensure that instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Instrumented Wheel set Installation, Calibration, and Operation, and PKRG-3900-TC On-track Test Phase II Test Setup. ______

4.1.4 Ensure that buffer cars are coupled to the core test consist as illustrated in Figure 2-2. ______

CAUTION

Restrict coupling speed to 3.5 mph.

4.2 On-track Test

TASK NUMBER | **PROCEDURE** | **QA INITIAL**

4.2.1 This test utilizes three different degrees of curvature and superelevation (7.5-, 10-, and 12-degree with 4, 3.4 and 5 inches of superelevation respectively) available on the WRM track.

4.2.1.1 Ensure applicable perturbations have been verified by the use of an optical transit and automatic levels. ______

4.2.1.2 Ensure pre-test sign off sheet PKRG-7002 has been completed. ______

4.2.2 Determine the test run speed by equation:

$$V = \sqrt{1480\frac{(U+H)}{D}}$$

Where: U = unbalance in inches
H = superelevation in inches
D = degree of curvature

Where: U = ______
H = ______
D = ______

4.2.3 For U = -3. 0, and 3 inches of unbalance.

NOTE

Track speed may be lower than the calculated speed for the +3 inches. If this condition exists use the track speed limit. The speed calculated for the -3 inches may be zero or less. If this condition exists use a negative difference from the balance equal to the positive difference for the +3 inches.

CAUTION

Stop testing when any L/V exceeds .8 or any axle sum L/V exceeds 1.3 for a period greater than 5 percent of time in steady state curving.

4.2.4 Operate the test consist at a constant speed for each condition shown in Table 4-1 (speeds shall be +/- 1 mph). Start testing with underbalance, then balance speed, ending with overbalance speed. For safety, additional intermediate speeds may be run.

Table 4-1 Constant Curving Conditions Matrix

DEGREE	SUPER ELEVATION	BALANCE SPEED	+3 INCH	-3 INCH
7.5	3	24.0	32.0	14.0*
10	3.4	24.0	32.0	12.0
12	5	25.0	32.0	16.0

* This speed is -2 inch unbalance; -3 inch is 0 mph

4.2.5 With each test run, record data 200 - 300 ft. before the curve and through the length of the body of the curve. The computer should be triggered by the ALD.

4.2.5.1 Repeat Step 4.2.4 for opposite directions.

4.2.6 Quality verify that the test matrix is complete. ______

215

4.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
4.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3900-TC.	_____
4.3.2	Carman perform Post Test Visual Inspection of train.	_____

NOTE

If defects are found then record on PKRG-2200.

5.0 SPIRAL NEGOTIATION AND WHEEL UNLOADING

5.1 Test Requirements

TASK NUMBER	PROCEDURE	QA INITIAL
5.1.1	This test will run concurrently with the Constant Curving Test.	
5.1.2	Ensure applicable perturbations have been verified.	_____
5.1.2.1	Ensure pre-test sign off sheet PKRG-7002 has been completed.	_____
5.1.3	Record data while running through the spirals on the WRM during the curving test.	

CAUTION

Stop testing when the vertical wheel force is less than 10 percent static wheel load or any wheel L/V exceeds 0.8 for 50 millisecond.

TASK NUMBER	PROCEDURE	QA INITIAL
5.1.4	Quality verify that the test is complete.	_____

6.0 TWIST AND ROLL TEST

6.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
6.1.1	Ensure that buffer cars are coupled to the core test consist as shown in Figure 2-2.	_____
6.1.2	Ensure that instrumentation meets the requirements outlined in PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3900-TC On-track Test Phase II Test Setup.	_____
6.1.3	Ensure that instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation, and PKRG-3900-TC On-track Test Phase II Test Setup.	_____

6.2 On-track Test

TASK NUMBER	PROCEDURE	QA INITIAL
6.2.1.	Ensure applicable perturbations have been verified by the use of an optical transit and automatic levels.	_____
6.2.1.1	Ensure pre-test sign off sheet PKRG-7002 has been completed.	_____
6.2.1.2	This test will be performed on the Precision Test Track (PTT).	
6.2.3	Approach the test zone at a constant speed of 5 mph, +/- 1 mph.	

NOTE

ENSCO Wheel Set Data not valid below 10 mph.

6.2.4 Record the wheel forces, mean roll angle and differences in roll between the ends for each truck for approximately 200 ft. before the test zone and continuously through the test zone.

CAUTION

Stop testing before the car body peak-to-peak roll exceeds 6 degrees, any single wheel L/V exceeds 0.8, any axle sum L/V exceeds 1.3 or any vertical wheel load measures less than 10 percent of its static wheel load.

6.2.5 Run tests at constant speeds, increasing in increments of 5 mph, +/- 1 mph until resonance is passed (expected resonance speed 13 mph +/- 1 mph for MLC and 16 mph for +/- 1 mph Triplet Cars calculated); then, increase speeds in increments of 5 mph +/- 1 mph.

6.2.6 In the Test Engineer's log note the speed at which resonance is reached.

6.2.7 Stop testing if an unsafe condition is encountered or when the maximum speed of 60 mph is reached. ______

6.2.8 Quality verify that the Twist and Roll Test is completed. ______

6.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
6.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3900-TC.	______
6.3.2	Carman perform Post Test Visual Inspection of train.	______

NOTE

If defects are found then record on PKRG-2200.

7.0 PITCH AND BOUNCE TEST

7.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
7.1.1	This test is to be performed to the PTT located between stations 1716+00 and 1719+90.	
7.1.2	Ensure that the buffer cars are coupled to the core test consist as shown in Figure 2-2.	______
7.1.3	Ensure that instrumentation meets the requirements outlined in PKRG-3400 IITRI 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG-3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation and PKRG-3900-TC On-track Test Phase II Test Setup.	______
7.1.4	Ensure that instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Instrumented Wheel Set Installation, Calibration and Operation, and PKRG-3900-TC On-track Test Phase II Test Setup.	______

7.2 On-track Test

TASK NUMBER	PROCEDURE	QA INITIAL
7.2.1	Ensure applicable perturbations have been verified.	______
7.2.1.1	Ensure pre-test sign off sheet PKRG-7002 has been completed.	______

7.2.2 Approach the test section at a constant speed of 30 mph, +/- 1 mph. Start recording test data approximately 200 ft. before the test section and continuously through the test section.

7.2.3 Using the information fed to the computer from the instrumented wheel sets, record the vertical wheel forces before and continuously through the test zone.

CAUTION

Stop testing when any wheel shows a vertical load of less than 10 percent of its static load for 50 millisecond.

7.2.4 Increase speed in increments of 5 mph +/- 1 mph until unsafe conditions are encountered, the resonance is passed or, a maximum of 60 mph +/- 1 mph is reached. Increments may be reduced to 2 mph +/-1 mph when nearing resonance. Resonance is expected at 46 mph +/- 1 mph. _____

7.2.5 Quality verify that the Pitch and Bounce Test is completed. _____

7.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
7.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3900-TC.	_____
7.3.2	Carman perform Post Test Visual Inspection of train.	_____

NOTE

If defects are found, record on PKRG-2200.

8.0 TURNOUT AND CROSSOVER TEST

8.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
8.1.1	Use whatever configuration the consist is in while traversing from one test section to the other.	
8.1.2	Ensure applicable perturbations have been verified.	_____
8.1.3	Ensure pre-test sign off sheet PKRG-7002 has been completed.	_____
8.1.4	This test will be performed on the turnouts and crossover on the RTT and TTT near post 85.	
8.1.5	The Triplet Consisit shall be run at 15 mph or less through a #10 car crossover with 13 feet track centers and through a 350 feet radius curve. The Triplet Consist shall be run through a # 8 turnout at 5 mph or less.	
8.1.6	Quality verify that the Turnout and Crossover Test is completed.	_____

9.0 SPECIAL PERTURBATIONS

9.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
9.1.1	If necessary, the consist may be run through special perturbations to be identified later.	

9.1.2 Test setup will be defined at that time.

9.2 On-track Test

TASK NUMBER	PROCEDURE	QA INITIAL
9.2.1	Test procedure and stop criteria will be identified later.	

9.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
9.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3900-TC.	______
9.3.2	Carman perform Post Test Visual Inspection of train.	______

NOTE

If defects are found then record on PKRG-2200.

10.0 DYNAMIC CURVING TEST

10.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
10.1.1	This test is to be conducted on the 10-degree curve (station 1+00 to 3+50) of the wheel/rail mechanism (WRM) track.	
10.1.2	Ensure that instrumentation meets the requirements outlined in PKRG 3400 IITRI 38" Instrumented Wheel Set Installation, Cali-	

bration and Operation, PKRG 3300 ENSCO 38" Instrumented Wheel Set Installation, Calibration and Operation, PKRG 3900-TC On-Track Test Phase II Test Setup.

10.1.3 Ensure that the instrumentation meets the requirements outlined in PKRG-3500 IITRI 36" Istrumented Wheel Set Installation, Calibration and Operation and PKRG-3900-TC On-Track Test Phase II Test Setup.

10.2 On-Track Testing

TASK NUMBER **PROCEDURE** **QA INITIAL**

10.2.1 This test will be run in both the clockwise and counterclockwise directions.

10.2.2 Ensure applicable perturbations have been verified. ________

10.2.3 Ensure pretest sign off sheet PKRG 7002 has been completed. ________

CAUTION

It shall be regarded as unsafe if any wheel L/V exceeds 1.1 for greater than 50 milliseconds for speeds of 20 mph or less, if any wheel L/V exceeds 1.0 for greater than 50 milliseconds for speeds greater than 20 mph or if any car body roll angle exceeds 6 degrees peak-to-peak. Stop the test when any of these conditions exist.

10.2.4 Approach the test zone at a constant speed of 10 MPH.

10.2.5 Start acquiring test data approximately 200 ft. before the test zone. Record the lateral and vertical wheel forces and the roll angle.

10.2.6 Increase speed in 2 mph increments until a maximum of 32 mph is reached or an unsafe condition is encountered.

10.2.7 Quality verify that the Dynamic Curving test is completed.

10.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
10.3.1	Perform Post Test Cal per PKRG 3300, 3400, and 3900-TC.	______
10.3.2	Perform Post Test Visual Inspection.	______

11.0 YAW AND SWAY TEST

11.1 Test Setup

TASK NUMBER	PROCEDURE	QA INITIAL
11.1.1	This test is to be conducted on section 21+00 to 26+00 of the PTT.	
11.1.2	Reconfigure the 38" Instrumented Wheel Set by repeating Steps 2.1.1 through 2.1.22 moving the Instrumented Wheel Set from Axle 6 to Axle 7 and moving the Instrumented Wheel Set from Axle 2 to Axle 3 as shown in Figure 11-1.	______

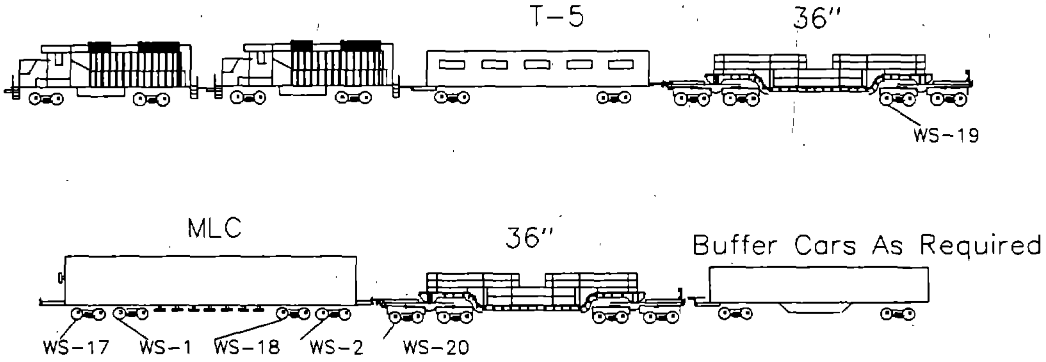

Figure 11-1 Yaw and Sway Instrumented Wheel Set Configuration

11.2 On-track Test

TASK NUMBER	PROCEDURE	QA INITIAL
11.2.1	Ensure applicable perturbations have been verified.	______
11.2.2	Ensure pre-test sign off sheet PKRG-7002 has been completed.	______
11.2.3	Ensure Instrumented Wheel Sets have been reconfigured as shown in Figure 11-1.	______
11.2.4	Ensure that the buffer cars are coupled to the core test consist as shown in Figure 11.1.	______
11.2.5	The initial test run is to be conducted at a constant speed of 20 mph +/- 1 mph and increasing in increments of 2 mph, +/- 1 mph until resonance is passed , then increase at 5 mph +/- 1 mph.	
11.2.6	Begin test data acquisition approximately 200 ft. before reaching the test section.	

CAUTION

It shall be regarded as unsafe conditions
if the ratio of the total lateral forces on any one
side measured exceeds 0.6 for a duration equivalent to 6 ft.
or any axle sum L/V exceeds 1.3 for 50 millisecond.
Stop the test when either condition exists

11.2.7	Repeat the test at speed increments of 2 mph, +/- 1 mph. The test will continue until an unsafe condition is encountered, the resonance is passed or the maximum speed of 60 mph +/- 1 mph is reached. Speed may be increased in increments of 5 mph +/- 1 mph when resonance is passed.	______
11.2.8	Quality verify that the Yaw and Sway Test is completed.	______

11.3 Post Test

TASK NUMBER	PROCEDURE	QA INITIAL
11.3.1	Perform Post Test Cal per PKRG 3300, 3400, 3500 and 3900-TC.	______
11.3.2	Carman perform Post Test Visual Inspection of train.	______

NOTE

If defects are found then record on PKRG-2200.

12.0 TEST CAR UNLOADING

TASK NUMBER	PROCEDURE	QA INITIAL
12.0.1	Unload car per Procedure-8100-Triplet Cars	
12.0.2	Quality verify unloading.	______

13.0 TEST TEAR DOWN

TASK NUMBER	PROCEDURE	QA INITIAL
13.0.1	The procedure for tear down of the ENSCO 38" Instrumented Wheel Sets is located in PKRG 3300, Section 5.0 through 5.1. Refer to this procedure and the applicable section to complete test tear down.	______
13.0.2	The procedure for tear down of the IITRI 38" Instrumented Wheel Sets is located in PKRG-3400, Section 6.0 through 6.1. Refer to this procedure and the applicable section to complete test tear down.	______

13.0.3 The procedure for tear down of the IITRI 36" Instrumented Wheel Set. Is located in PKRG-3500, Section 7.0. Refer to this procedure and the applicable section to complete test tear down. _____

13.0.4 Carman perform car inspection PKRG-2200. _____

13.0.5 If required, perform internal inspection of the MLC by removing section(s) of the roof.

14.0 QUALITY VERIFICATION

TASK NUMBER	PROCEDURE	QA INITIAL
14.0.1	Quality verified that Procedure PKRG-9000-TC On-track Test Phase II Test Setup complete and closed.	
14.0.2	Authorized QA signature ______________________.	

(4)

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-3900-TC
ON-TRACK TEST PHASE II TEST SETUP

228

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-3900-TC
ON-TRACK TEST PHASE II TEST SETUP

1.0 DESCRIPTION

The purpose of this procedure is to outline the sequence of steps to be taken for the Rail Garrison On-Track Test Phase II Test Setup to be performed on two commercial span bolster cars (Triplet Cars) and the Missile Launch Car (MLC).

1.1 INDEX

1.2 EQUIPMENT LIST

a.	4 ea.	38" Instrumented Wheel Set Systems
b.	2 ea.	36" Instrumented Wheel Set Systems
c.	8 ea.	Junction Boxes
d.	1 ea.	Automatic Location Detector
e.	1 ea.	Wheel Tachometer
f.	1 ea.	IRIG-B Time Code Receiver
g.	1 ea.	IRIG-B Decoder
h.	4 ea.	String Pot, +/- 1" range
i.	8 ea.	String Pot, +/- 5" range
j.	4 ea.	String Pot +/- 10" range
k.	22 ea.	Accelerometer +/- 5g range
l.	4 ea.	Accelerometer +/- 15g range
m.	3 ea.	Accelerometer +/- 25g range
m.	2 ea.	Rate Gyro +/- 8 degree range
o.	1 ea.	Instrumented Coupler, +/- 200 KIP range
p.	1 ea.	Thermocouple, - 50 to + 100 degree Fahrenheit
q.	2 ea.	Inclinometer, +/- 10-degree range
r.	2 ea.	Strain Gage Bending Bar, +/- 1" range
s.	1 ea.	HP 9000 model 360 Computer System
t.	1 ea.	HP 6944A Multi-programmer
u.	1 ea.	Dot X 205 Rail Test Vehicle
v.	As needed	Safety Equipment as required by TTC
w.	1 ea.	Instrumented Coupler, +/- 1,000 KIP range

1.3 FIGURE LIST

1.4 TABLE LIST

None

1.5 REFERENCE LIST

PKRG-2100	Truck Inspection Procedure
PKRG-2200	Car Inspection Procedure
PKRG-3100	Instrumentation Installation Procedure
PKRG-3200	Instrumentation Verification Procedure
PKRG-3300	ENSCO 38" Instrumented Wheel Set Procedure
PKRG-3500	IITRI 36" Instrumented Wheel Set Procedure
PKRG-3400	IITRI 38" Instrumented Wheel Set Procedure
AAR/TTC	Instrumentation SOP NO.024 9/89
AAR/TTC	Rate Gyro Setup and Calibration Procedure
M1001	Manual Of Standards and Recommend Practices, C, Part II, Volume I, Chapter XI
	Instrum 2702 Signal Conditioner Setup Procedure
	TTC Operation Rules for the Transportation Test Center, Pueblo, Colorado, AAR, November 1, 1989
	Peacekeeper Rail Garrison Test Implementation Plan, (for appropriate test car), Chapter XI Testing

NOTE

All personnel involved in the performance of this procedure or observing the test(s) will comply with the TTC Safety Rule Book.

2.0 ON TRACK TESTING PHASE II TEST SETUP PROCEDURES

2.1 Test Setup Procedures

TASK NUMBER	PROCEDURE	QA INITIAL
2.1.1	Install instrumented wheel sets by following the instrumented wheel set procedures PKRG-3500, PKRG-3400 and PKRG-3300.	
2.1.2	Couple test vehicle and locomotive to the Dot X 205 Rail Test Vehicle as illustrated in Figure 2-1. Comply with TTC Operating Rules.	

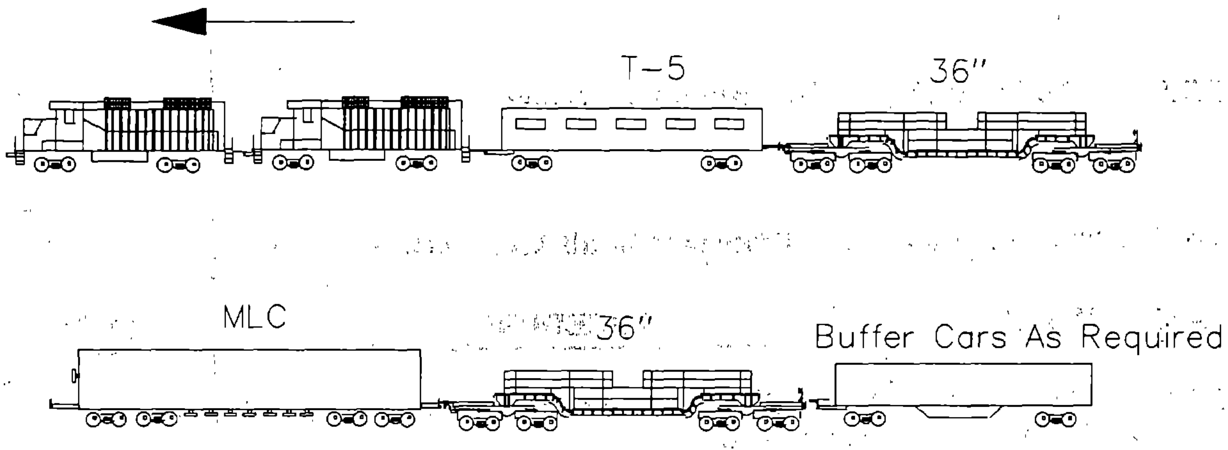

Figure 2-1 Vehicle Configuration

NOTE

Calibration procedures will be accomplished at the start of each test day for all the following tasks.

2.2 Instrumented Wheel Set Calibration Procedure.

TASK NUMBER	PROCEDURE	QA INITIAL
2.2.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.2.2	Refer to the appropriate instrumented wheel set procedure: PKRG-3500 Installation, Calibration and Operation of IITRI 36" Instrumented Wheel Sets. PKRG-3400 Installation, Calibration and Operation of IITRI 38" Instrumented Wheel Set Procedure and PKRG-3300 Installation, Calibration and Operation of ENSCO 38" Instrumented Wheel Set Procedure.	______
2.2.3	Print checkout values and label Pre-test Instrumented Wheel Set Zeros.	
2.2.4	Print checkout values and label Pre-test Instrumented Wheel Set RCAL.	
2.2.5	Quality verify wheel set calibration is complete.	______

2.3 Accelerometer Calibration Procedure for all Accelerometer Channels.

TASK NUMBER	PROCEDURE	QA INITIAL
2.3.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.3.2	Refer to Test Measurement List for layout (18 sheets attached at end).	
2.3.3	Install accelerometers in accordance with AAR/TTC Instrumentation SOP NO. 024 9/89 (attached at end).	______

2.3.4 Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Sections 8,9). ______

2.3.5 Monitor excitation and adjust excitation to voltage specified in the configuration data sheet to within +/- 10mv.

2.3.6 Position the function knob to INPUT SHORT.

2.3.7 Adjust the DC offset of the conditioner to zero +/- 2 mV.

2.3.8 Position the function knob to DATA mode.

2.3.9 Adjust the balance pot for zero volts +/- 10 mv.

2.3.10 Place the function knob to the CAL mode position.

2.3.11 Verify cal output equals the configuration data sheet.

2.3.12 Place all accelerometers in the DATA mode, print out values and label Pre-test Accelerometer Zeros.

2.3.13 Place all accelerometers in the CAL mode, print out values and label Pre-test Accelerometer RCAL's.

2.3.14 Place all accelerometer channels back to the DATA mode.

2.3.15 Quality verify all accelerometer calibration has been completed. ______

2.4 String Pot Calibration Procedure for all String Pots.

TASK NUMBER	PROCEDURE	QA INITIAL
2.4.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.4.2	Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Section 9).	______
2.4.3	Monitor the excitation and adjust to + 10.0 VDC +/- 5 mV.	
2.4.4	With the function knob in the INPUT SHORT position, adjust the DC offset of the conditioner to zero +/- 2 mV.	
2.4.5	Position the function knob to DATA mode.	
2.4.6	Adjust the balance pot for zero volts +/- 10 mV.	
2.4.7	With all the string pot channels in the DATA mode, print out values and label Pre-test String Pot Zero.	
2.4.8	Place all string pot channels in the CAL mode, then print out the values and label Pre-test String Pot RCAL's.	
2.4.9	Place all string pot channels back to the DATA mode.	
2.4.10	Qualify verify completion of string pot calibration.	______

2.5 Rate Gyro Calibration Procedure for all Rate Gyros.

TASK NUMBER	PROCEDURE	QA INITIAL
2.5.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.5.2	Mount gyros onto gyro rotation platform. Mount gyro platform at appropriate locations.	
2.5.3	Ensure 28 volt gyro rotation power is on.	
2.5.4	Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Section 9).	______
2.5.5	Monitor the excitation voltage and adjust to +10.00 VDC +/- 10 mV.	
2.5.6	With the function knob in the INPUT SHORT position, adjust the DC offset of the conditioner to zero +/- 2 mV.	
2.5.7	Position the function knob to DATA mode.	
2.5.8	Adjust the balance pot for zero +/- 10 mV.	
2.5.9	With all the gyro channels in the DATA mode, print out values and label Pre-test Gyro Zero.	
2.5.10	Place all the gyro channels in the CAL mode, wait approximately one minute, then print out the values and label Pre-test Gyro RCAL's.	
2.5.11	Place all gyro channels back to the DATA mode.	

2.5.12 Refer to AAR/TTC Rate Gyro Setup and Calibration Procedure and perform necessary steps for the gyro integrator unit.

2.5.13 Quality verify that all gyro calibration has been completed. ______

2.6 Strain Gaged Bending Beam Calibration Procedure for all Strain Gaged Bending Beams.

TASK NUMBER	PROCEDURE	QA INITIAL
2.6.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.6.2	Mount all strain gaged bending beams in accordance with AAR/TTC Instrumentation SOP NO. 024 9/89.	______
2.6.3	Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Section 6).	______
2.6.4	Monitor the excitation voltage and adjust to +10.00 +/- 10 mV.	
2.6.5	With the function knob in the INPUT SHORT position, adjust the DC offset of the conditioner to zero +/- 3 mV.	
2.6.6	Position the function knob to DATA mode.	
2.6.7	Adjust the balance pot for zero volts +/- 10 mV.	
2.6.8	With all the strain gaged bending beam channels in the DATA mode, print out values and label Pre-test Strain Gaged Bending Beam Zero.	

2.6.9 Place all the strain gaged bending beam channels in the CAL mode, then print out the values and label Pre-test Strain Gaged Bending Beam RCAL's.

2.6.10 Place all strain gaged bending beam channels back to the DATA mode.

2.6.11 Quality verify all couplers and strain gages have been calibrated. ______

2.7 Inclinometer Calibration Procedure for all Inclinometers.

TASK NUMBER	PROCEDURE	QA INITIAL
2.7.1	Refer to procedure PKRG-3100 for completing the Test Configuration Data Sheet, Section 5.1-5.8.	______
2.7.2	Mount all inclinometers.	
2.7.3	Refer to Instrum 2702 Signal Conditioner Setup Procedure for setup (Section 9).	______
2.7.4	Monitor the excitation voltage and adjust to + 10.00 mV.	
2.7.5	With the function knob in the INPUT SHORT position, adjust the DC offset of the conditioner to zero + /- 2 mV.	
2.7.6	Position the function knob to DATA mode.	
2.7.7	Adjust the balance pot for zero volts + /- 10 mV.	
2.7.8	With all the inclinometers channels in the DATA mode, print out values and label Pre-test Inclinometer Zero.	

2.7.9 Place all inclinometer channels in the CAL mode, then printout the values and label Pre-test Inclinometer RCAL's.

2.7.10 Place all inclinometer channels back to the DATA mode.

2.7.11 Quality verify inclinometer channels have been calibrated. ______

3.0 ON-TRACK TESTING PHASE II

TASK NUMBER	PROCEDURE	QA INITIAL
3.1	Perform testing as required by individual vehicle test plan.	

4.0 QUALITY VERIFICATION

TASK NUMBER	PROCEDURE	QA INITIAL
4.1	Quality verify that PKRG-3900-TC is complete and closed.	
4.2	Authorized QA signature______________________________.	

INSTURM 2702 SIGNAL CONDITIONER SETUP PROCEDURE

I. INTRODUCTION: This procedure is provided as a supplement to the Manufacture Instruction Manual to organize information required in everyday use of the 2702 amplifiers. This procedure should allow instrumentation personnel not familiar with this equipment to setup and operate the hardware and make minor configuration changes needed in normal operation.

This signal conditioning is very flexible and can be configured for many types of transducers.

This signal conditioning provides these features:

* **Excitation**-0 to 30 DC volts operating voltage
* **Amplification-** Gain to 12500 times transducer out
* **Filtering-** 4 pole Bessel elimination of undesired data
* **Common Mode Rejection-** 120dB. With up to 1000 ohms unbalance
* **Calibration-** Shunt or voltage insertion capability
* **Balancing-** Automatic and / or manual correction for input imbalance
* **Input Wiring**- Plug in configuration cards for up to 10 wire input wiring.

II. This document will concentrate on conditioning the most common type transducer now in use and will not attempt to replace the instruction manual and its theory of operation.

SYSTEM CONFIGURATION
The Instrum 2702 system is composed of a 10 channel Mainframe cabinet and amplifier modules with a front panel plug-in containing input configuration cards. This configuration card selects the type of balancing, calibration and input wiring scheme for each transducer and will be discussed in more detail under each transducer type description

240

III. FRONT PANEL CONTROLS

The amplifier controls and test points required for normal operation are allocated on the front panel except for the main frame power switch and fuse on rear panel and output No. 2 filter switch inside the amplifiers right side cover. A brief description of the controls follows:

1. Gain Switch Located on bottom center of front panel and provides fixed gain steps of 1,2,5,10,20,50,100,200,500,1000,2000, and 5000.

2. Variable Gain Switch Allows multiplying the fixed gain switch setting up to 2.5 times. Use of this feature is indicated by a red LED on the lower left side of the instrument between the variable gain switch and variable gain screwdriver adjustment. (Use of variable gain is not recommended as a standard procedure.)

3. Filter Switch This switch near the bottom of the amplifier provides for selection of 15,30,120, or 360 hz. For internal forth order Bessel output filters. The fifth position is W.B. or wideband which bypasses any output filtering.

4. Output Monitor This pair of test points monitors output 1 and is used to set up signal conditioner.

5. Excitation Switch, This locking toggle switch provides for selection of 0-10, 10-20, and 20-30 volts DC and is located at the top of the front panel.

6. Level Control This screwdriver adjustment varies the excitation over the range selected by the excitation switch and is physically located right under the excitation switch.

7. Ex Test Points These pin jacks monitor the excitation set by the level control and are on the left side of the front panel near the middle.

8. In Monitor Points These pin jacks monitor the amplifier input after all signal conditioning such as balancing, input filtering or attenuation is complete. These points are on the left side of the front panel in the model 2059 plug-in.

9. Xd Monitor Points The pin jacks monitor the transducer output prior to any conditioning and are located on the left side of the model 2059 plug-in module.

10. Mode Select Switch This four position switch located in the model 2059 plug-in module is used to short amplifier input and to adjust offset controls, energizing calibration relays, selecting auto balance function or normal (data) mode. *Note* an extra, non-operational position exists in the clockwise direction.

11. Bal/Bias Adjustment. This 10k potentiometer is used with R1 (user supplied) to provide manual control of the input balance (bias) voltage. This control might need adjustment to obtain proper auto balance range and fine balance.

12. Zero RTI Control. Provides mean of adjusting input stage DC offset when required. This adjustment is normally required after maintenance or repair.

13. Zero RTO Control This screwdriver adjustment is for control of the amplifier final stage offset, if required, and is located on the lower left front panel.

IV. USER SUPPLIED COMPONENTS

The model 2059 has provisions for soldering up to 10 resistors, capacitors or jumper wires to provide flexibility in input circuits. Specific purpose for each component will be listed under transducer type description. All components installed in these input circuits should be high quality, high stability parts to assure long term stable operation.

V. GENERAL OPERATING SEQUENCE

This section describes the normal procedures used for most measurement setups. Specific transducers are discussed in the following paragraphs.

1. Select transducer type and obtain calibration data.

2. Obtain proper configuration card and transducer input cable for selected transducer type.

3. Start data acquisition set-up form.

4. Install transducer using proper mounting technique for desired measurement.

5. Install transducer cable to proper amplifier input connector.

6. Install plug-in module after verifying voltage range selector on proper range and correct resistors are installed.

7. Turn on amplifier power.

8. Set desired excitation per calibration data manufactures data or test plan.

9. Place amplifier front panel control to short position and while monitoring output from front panel adjust RTO potentiometer to 0.000+/-.002 volts DC.

10. Set gain to fixed range determined from test requirements and calibration data.

11. Set front panel control to auto balance. A slow blinking green LED on front panel indicates proper balancing. If blinking becomes rapid, an input problem such as: improper configuration card, wrong transducer wiring, or a bad transducer is indicated correct this problem before proceeding. If auto balance span is too limited try auto balance at a lower gain and reset gain if good null obtained.

12. After autobalance is achieved, as indicated by steady green LED, switch to data position and verify satisfactory balance. Bal/bias adjustment will allow fine setting if required.

13. Switch to Cal position and record calibration output voltage on data acquisition form.

14. Return front panel switch to data position.

VI. FULL BRIDGE MEASUREMENTS

To use the 2702 with 4 leg or full bridge input transducers such as strain gage circuits, install an Instrum type "H" configuration card in the 2059 plug-in. Typical values for the plug-in and there functions are listed below:

R1	100k ohms	Balance Limit
R2	Short	Input filter
C1	Open	Input filter
R3	Short	Input filter
R4	Open	Not Used
R5	Open	Not Used
R6	100k ohms	Auto Balance Limit
R7	Open	Not Used
R8	xxx.ohms	Shunt Calibration
R9	Open	Not Used

The value of R8 to be determined from the transducer calibration data or from the following equations:

$$Es = \frac{Rg x 10^{(-6)}}{K x (Rsh + Rg)}$$

$$Eo = \frac{E1 \times K \times Es}{4}$$

Where
Rsh = R8 = ohms
Rg = Gage = ohms
Es = Simulated strain
K = Gage factor
Eo = Bridge volts output
E1 = Excitation volts

In setting up the signal conditioning, excitation should be determined from the manufacturer's power dissipation data for that type of measurement. The general rule is to use the highest excitation that gives the required stability, but never exceed the manufacture's safe excitation level.

VII. LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT)

The signal conditioners are set up to provide excitation isolation and gain for DC powered LVDT's by installing a type "K" Instrum

244

configuration card in the 2059 plug-in. Have these transducers set up for voltage substitution calibration and auto balancing. Typical values for user installed components are listed below:

R1	10k ohms	Main Balance Span
R2,R3	Short	Input Filter
C1	Open	Input Filter
R4	Open	Not Used
*R5	5k ohms	Balance Range
R6	10k ohms	Auto Balance Limit
R7	20k ohms	Voltage Sub Divider
R8	1-20k ohms	Voltage Sub Divider
R9	Short	

* Should be 1 to 10k using lowest value needed to obtain balance span desired.
Voltage sub can be calculated using the following equation.

$$Vsub = \frac{R8 \times 10}{R7+R8}$$

VIII. SETRA 141A ACCELEROMETERS

With the type "J" Instrum configuration card installed in the model 2059 plug-in, and with proper selection of the user installed components, the 2702 will provide excitation, auto balancing (+/- 1g input), gain, filtering and shunt calibration. The nominal values of user supplied components are as listed below for subject accelerometers.

R1, R6	20-100k ohms	Balance Limiting
R5	2k ohms	Balance Span
R2,R3	Short	Input Filter
C1	Open	Input Filter
R8	100k ohms	*see note
R9	1n4746A	Over-voltage Protection

NOTE 100k across calibration lead will provide approximately .1 volt output. Actual voltage for each installed accelerometer should be accurately measured at the input and also referring to the calibration data determine the equivalent "g" reading. This resistor value can be raised to simulate less output or lowered to produce more signal.

Prior to installing the plug-in in the amplifier, verify the excitation range switch is in the 0-10 volt position. Adjust excitation to 10.0 volts and verify desired gain setting (50 or less). Switch selector to auto balance while monitoring output. Balance will be obtained in about 45 seconds. If the green LED blinks rapidly corrective action is required. After balance is obtained set switch to data or cal position. Never leave in Auto position after switching from any other position or a new balance will be obtained. Any time auto balance is terminated prior to completion, the old balance setting is restored. In this configuration, the calibration output is added to the transducer output. Therefore if there is .02 volt unbalance or signal caused be grade or superelevation etc, the output will be equal to the cal voltage plus offset or .02 +.1 or .12 VDC.

IX. POTENTIOMETER SERO ACCELEROMETER AND VOLTAGE INPUT CONFIGURATION

This configuration card (type "K") is the same used for the DC/DC LVDT's (section VII) but uses slight changes to the plug-in card components. The main difference in using it for voltage inputs is to eliminate the wiring input cabling to provide excitation. This card, however, is designed to excite and accept inputs from almost any DC powered transducer. Typical use for voltage input would be to buffer (isolate) signals from other systems. Typical values for the user installed components and there functions are listed below.

R1,R6	50-100k ohms	Balance Range
R2,R3	Short	Input Filter
C1	Open	Input Filter
R4	Open	Input Attenuation
R5	1-10k ohm	Balance Current
R7	10k minimum	Voltage Substitution

R8	1 10k ohm	Volt Sub Divider
R9	Short	Input Attenuation

*Use lowest value needed to obtain desired balance span.

Voltage substitution (Vsub) can be calculated using the formula:

$$\text{Vsub} = \frac{R8 \times 10}{R7+R8}$$

X. AMPLIFIER ZERO AND INITIAL SETUP

This section defines checking and adjusting the amplifier zero:

1. Set front panel control to short position.

2. Set gain to 1000 (fixed) and note output No. 1 Voltage.

3. Switch to gain = 1 and note output.

4. Adjust RTI control so that step 2 output = step 3 output.

5. Repeat steps 2,3 and 4 until output is constant.

6. Adjust output with RTO control for 0.000 +/- 1 mv Dc.

7. If second output is being used and a offset is noted, refer to instruction manual for bench instruction procedure.

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 1 OF 10

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE 2-1-91 W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. SET-UP FILE
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. MIF_TRIP10

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ.	GAIN	CAL VOID DATE	AO (E.U.)	AI (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV)	
ALD	0	0	XOX 001A	VARNER		20 ms PULSE	X= Y= Z=												0	1 EVENT 10V	EVENT	16		ALD
SPD	1	1	ROW 001D	AIR PAX		64 PULSE/REV	X= Y= Z=												0	10 MPH/V	MPH	8		SPEED
FV1R	2	2	LBV 001A	IITRI	19 A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	1		36' IWS VERT RT CAR-1 LEAD AXLE TRK-3
FV1L	3	3	LBV 002A	IITRI	19 B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	2		36' IWS VERT LF CAR-1 LEAD AXLE TRK-3
FL1R	4	4	LBV 003A	IITRI	19 A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	3		36' IWS LAT RT CAR-1 LEAD AXLE TRK-3
FL1L	5	5	LBV 004A	IITRI	19 B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	4		36' IWS LAT LF CAR-1 LEAD AXLE TRK-3
LV1R	6	6	LBV 005A	IITRI	19 A	CALC	X= Y= Z=									15 Hz	1		0	.5 KIPS/V	KIPS	5		36' IWS L/V RT CAR-1 LEAD AXLE TRK-3
LV1L	7	7	LBV 006A	IITRI	19 B	CALC	X= Y= Z=									15 Hz	1		0	.5 KIPS/V	KIPS	6		36' IWS L/V LF CAR-1 LEAD AXLE TRK-3
FT1	8	8	LBV 007A	IITRI	19	CALC	X= Y= Z=									15 Hz	1		0	3.4 KIPS/V	KIPS	7		36' IWS TORQUE CAR-1 LEAD AXLE TRK-3
FV2R	9	9	LBV 008A	IITRI	17 A	CALC	X= 892 Y= -28.5 Z= 19									15 Hz	1		0	10.246 KIPS/V	KIPS	9		38' IWS VERT RT MLC LEAD AXLE TRK-1

NOTES:

ACAD FILE: TRIP201.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 2 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF_TRIP10
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO	FREQ	GAIN	CAL VOID DATE	A0 (E.U.)	A1 (E.U./VOLT)	ENGR UNITS	CH NO.	SENS. (E.U./DIV.)	
FV2L	10		LBW 009A	IITRI	17B	CALC	X= 892 Y= 28.5 Z= 19									15 Hz	1		0	10.246 KIPS/V	KIPS	10		38'IWS VERT LF MLC LEAD AXLE TRK-1
FL2R	11		LBW 010A	IITRI	17A	CALC	X= 892 Y= -28.5 Z= 19									15 Hz	1		0	10.246 KIPS/V	KIPS	11		38'IWS LAT RT MLC LEAD AXLE TRK-1
FL2L	12		LBW 011A	IITRI	17B	CALC	X= 892 Y= 28.5 Z= 19									15 Hz	1		0	10.246 KIPS/V	KIPS	12		38' IWS LAT LF MLC LEAD AXLE TRK-1
LV2R	13		LBW 012A	IITRI	17A	CALC	X= 892 Y= -28.5 Z= 19									15 Hz	1		0	.5 L/V /V	KIPS	13		38'IWS L/V RT MLC LEAD AXLE TRK-1
LV2L	14		LBW 013A	IITRI	17B	CALC	X= 892 Y= 28.5 Z= 19									15 Hz	1		0	.5 L/V /V	KIPS	14		38'IWS L/V LF MLC LEAD AXLE TRK-1
FT2	15		LBW 014A	IITRI	17	CALC	X= 892 Y= 0 Z= 19									15 Hz	1		0	6.67 KIPS/V	KIPS	15		38' IWS TORQUE MLC LEAD AXLE TRK-1
FV3R	16		LBW 015A	ENSCO	1A	CALC	X= 1036 Y= -28.5 Z= 19									15 Hz	1		0	7.5 KIPS/V	KIPS	17		38'IWS VERT RT MLC LEAD AXLE TRK-2
FV3L	17		LBW 016A	ENSCO	1B	CALC	X= 1036 Y= 28.5 Z= 19									15 Hz	1		0	7.5 KIPS/V	KIPS	18		38 IWS VERT LF MLC LEAD AXLE TRK-2
FL3R	18		LBW 017A	ENSCO	1A	CALC	X= 1036 Y= -28.5 Z= 19									15 Hz	1		0	6 KIPS/V	KIPS	19		38' IWS LAT RT MLC LEAD AXLE TRK-2
FL3L	19		LBW 018A	ENSCO	1B	CALC	X= 1036 Y= 28.5 Z= 19									15 Hz	1		0	6 KIPS/V	KIPS	20		38' IWS LAT LF MLC LEAD AXLE TRK-2

NOTES:

ACAD FILE: TRIP202.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 3 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________ MIF_TRIP10

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ	GAIN	CAL VOID DATE	A0 (E.U.)	A1 (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV.)	
LV3R	20	20	LBV 019A	ENSCO	1A	CALC	X= 1036 Y= -28.5 Z= 19									15 Hz	1		0	.25 L/V /V	L/V	21		38' IWS L/V RT MLC LEAD AXLE TRK 2
LV3L	21	21	LBV 020A	ENSCO	1B	CALC	X= 1036 Y= 28.5 Z= 19									15 Hz	1		0	.25 L/V /V	L/V	22		38' IWS L/V LF MLC LEAD AXLE TRK 2
FT3	22	22	LBV 021A	ENSCO	1	CALC	X= 1036 Y= 0 Z= 19									15 Hz	1		0	2 KIPS/V	KIPS	23		38' IWS TORQUE MLC LEAD AXLE TRK 2
FV4R	23	23	LBV 022A	IITRI	18A	CALC	X= 1634 Y= -28.5 Z= 19									15 Hz	1		0	10.246 KIPS/V	KIPS	25		38' IWS VERT RT MLC LEAD AXLE TRK 3
FV4L	24	24	LBV 023A	IITRI	18B	CALC	X= 1634 Y= 28.5 Z= 19									15 Hz	1		0	10.246 KIPS/V	KIPS	26		38' IWS VERT LF MLC LEAD AXLE TRK 3
FL4R	25	25	LBV 024A	IITRI	18A	CALC	X= 1634 Y= -28.5 Z= 19									15 Hz	1		0	10.246 KIPS/V	KIPS	27		38' IWS LAT RT MLC LEAD AXLE TRK 3
FL4A	26	26	LBV 025A	IITRI	18B	CALC	X= 1634 Y= 28.5 Z= 19									15 Hz	1		0	10.246 KIPS/V	KIPS	28		38' IWS LAT LF MLC LEAD AXLE TRK 3
FL4L	27	27	LBV 026A	IITRI	18A	CALC	X= 1634 Y= -28.5 Z= 19									15 Hz	1		0	.5 L/V/V	L/V	29		38' IWS L/V RT MLC LEAD AXLE TRK 3
LV4L	28	28	LBV 027A	IITRI	18B	CALC	X= 1634 Y= 28.5 Z= 19									15 Hz	1		0	.5 L/V/V	L/V	30		38 IWS L/V LF MLC LEAD AXLE TRK 3
FT4	29	29	LBV 028A	IITRI	18	CALC	X= 1634 Y= 0 Z= 19									15 Hz	1		0	6.67 KIPS/V	KIPS	31		38' IWS TORQUE MLC LEAD AXLE TRK 3

NOTES:

ACAD FILE: TRIP203.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 4 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS

INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________

SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF_TRIP10

SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.- L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ.	GAIN	CAL VOID DATE	AO (E.U.)	AI (E.U./VOLT)	ENGR UNITS	CH. NO.	SENS. (E.U./DIV.)	
FV5R	30	30	LBW 029A	ENSCO	2A	CALC	X= 1778 Y= -28.5 Z= 19									15 Hz	1		0	7.5 KIPS/V	KIPS	33		38' IWS VERT RT MLC LEAD AXLE TRK-4
FV5L	31	31	LBW 030A	ENSCO	2B	CALC	X= 1778 Y= 28.5 Z= 19									15 Hz	1		0	7.5 KIPS/V	KIPS	34		38' IWS VERT LF MLC LEAD AXLE TRK-4
FV5R	32	32	LBW 031A	ENSCO	2A	CALC	X= 1778 Y= -28.5 Z= 19									15 Hz	1		0	6 KIPS/V	KIPS	35		38' IWS LAT RT MLC LEAD AXLE TRK-4
FL5L	33	33	LBW 032A	ENSCO	2B	CALC	X= 1778 Y= 28.5 Z= 19									15 Hz	1		0	6 KIPS/V	KIPS	36		38' IWS LAT LF MLC LEAD AXLE TRK-4
LV5R	34	34	LBW 033A	ENSCO	2A	CALC	X= 1778 Y= -28.5 Z= 19									15 Hz	1		0	.25 L/V /V	L/V	37		38' IWS L/V RT MLC LEAD AXLE TRK-4
LV5L	35	35	LBW 034A	ENSCO	2B	CALC	X= 1778 Y= 28.5 Z= 19									15 Hz	1		0	.25 L/V /V	L/V	38		38' IWS L/V LF MLC LEAD AXLE TRK-4
FT5	36	36	LBW 035A	ENSCO	2	CALC	X= 1778 Y= 0 Z= 19									15 Hz	1		0	2 KIPS/V	KIPS	39		38' IWS TORQUE MLC LEAD AXLE TRK-4
FV6R	37	37	LBW 036A	IITRI	20A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	41		36' IWS VERT RT CAR-3 LEAD AXLE TRK-1
FV6L	38	38	LBW 037A	IITRI	20B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	42		36' IWS VERT LF CAR-3 LEAD AXLE TRK-1
FL6R	39	39	LBW 038A	IITRI	20A	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	43		36' IWS LAT RT CAR-3 LEAD AXLE TRK-1

NOTES:

ACAD FILE: TRIP204.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 5 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONIAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF TRIP10
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ.	GAIN	CAL VOID DATE	A0 (E.U.)	A1 (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV.)	
FL6L	40		LBV 039A	IITRI	20B	CALC	X= Y= Z=									15 Hz	1		0	10.246 KIPS/V	KIPS	44		36' IWS LAT LF CAR-3 LEAD AXLE TRK-1
LV6R	41		LBV 040A	IITRI	20A	CALC	X= Y= Z=									15 Hz	1		0	0.5 L/V /V	L/V	45		36' IWS L/V RT CAR-3 LEAD AXLE TRK-1
LV6L	42		LBV 041A	IITRI	20B	CALC	X= Y= Z=									15 Hz	1		0	0.5 L/V /V	L/V	46		36' IWS L/V LF CAR-3 LEAD AXLE TRK-1
FT6	43		LBV 042A	IITRI	20	CALC	X= Y= Z=									15 Hz	1		0	3.4 KIPS/V	KIPS	47		36' IWS TORQUE CAR-3 LEAD AXLE TRK-1
SP1	44						X= Y= Z=																	SPARE
JBX1	45		JBX 001A	HUMPHREY	111	3.951 DEG/V	X= Y= Z=	2-17-91	K	10 V	1 FIX	VSUB				15 Hz				0.988 DEG/V	DEG			CAR BODY ROLL ANGLE A-END CAR-1
AZ1	46		AZ1L	ENDEVCO 7290	AC 55	198.7 MV/G	X= Y= Z=	10-9-90	K	15 V	2 FIX	VSUB	3.342 V			120 Hz				2.516 G/V	G			ACCEL VERT CAR-1 ABOVE SPAN BLST 1
AZ2	47		AZ2L	ENDEVCO 7290	AC 99	197.9 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.320 V			120 Hz				2.527 G/V	G			ACCEL VERT CAR-1 CAR CTR FLOOR
AZ3	48		AZ3L	ENDEVCO 7290	AD 66	205.1 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.328 V			15 Hz				2.438 G/V	G			ACCEL VERT CAR-1 ABOVE SPAN BLST 2
AY1	49		AY1L	ENDEVCO 7290	AK 33	199.6 MV/G	X= Y= Z=	10-9-90	K	15 V	2 FIX	VSUB	3.332 V			120 Hz				2.505 G/V	G			ACCEL LAT CAR-1 ABOVE SPAN BLST 1

NOTES:

ACAD FILE: TRIP205.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 6 OF

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA
SOFTWARE/VERSION xCONTAQ8BB / RECORDER I.D. NO.
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO.
SET-UP FILE MIF_TRIP10

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ	GAIN	CAL VOID DATE	AO (E.U.)	AI (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV)	
AY2	50	50	AY2L	ENDEVCO 7290	AD 83	196.6 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.323 V			120 Hz	1			2.543 G/V	G			ACCEL CAR-1 LAT CTR FLOOR
AY3	51	51	AY3L	ENDEVCO 7290	AE 27	197.4 MV/G	X= Y= Z=	10-9-90	K	15 V	2 FIX	VSUB	3.326 V			15 Hz				2.533 G/V	G			ACCEL CAR-1 LAT ABOVE SPAN BLST 2
AX1	52	52	AXIL	ENDEVCO 7290	AC 41	176.4 MV/G	X= Y= Z=	10-10-90	K	15 V	2 FIX	VSUB	3.321 V			15 Hz				2.834 G/V	G			ACCEL CAR-1 LONG ABOVE SPAN BLST 1
AX2	53	53	AX2L	ENDEVCO 7290	AE 36	198.5 MV/G	X= Y= Z=	10-13-90	K	15 V	2 FIX	VSUB	3.317 V			15 Hz				2.519 G/V	G			ACCEL CAR-1 LONG ABOVE SPAN BLST 2
SP2	54	54					X= Y= Z=																	SPARE
JBX2	55	55	JBX 002A	HUMPHREY	118	4.000 DEG/V	X= 850 Y= 0 Z= 58	2-17-91	K	10 V	1 FIX	VSUB				15 Hz	1			1.000 DEG/V	DEG			B-END MLC CARBODY ROLL ANGLE
DBX1	56	56	DBX 001A	CELESCO	A 45654	0.4724 V/IN	X= 850 Y= 18 Z= 41	8-3-91	K	10 V	1 FIX	VSUB				15 Hz	1			2.117 IN/V	INCHS			B-END MLC COUPLER ANGLE LF
DBX2	57	57	DBX 002A	CELESCO	A 46550	0.4730 V/IN	X= 850 Y= -18 Z= 41	8-3-91	K	10 V	1 FIX	VSUB				15 Hz	1			2.114 IN/V	INCHS			B-END MLC COUPLER ANGLE RT
IC1	58	58	IC LC1	MINOR	WKP 2-1	.6727 mv/v	X= 827 Y= 0 Z= 34	5-17-91	HI	10 V	VAR	442 K	88.66552 -4.433 V			15 Hz	1			20 KIPS/V	KIPS			B-END MLC INSTRUMENTED COUPLER
LTV1	59	59	LTHD V1	Columbia SA-101-HP	1573	1555 mv/G	X= 900 Y= 39.5 Z= 14		K	30 V	50 ** FIX		10.913 V			15 Hz	1			0.0192 G/v	G			LTHD VERT TRK-1 MLC LF SIDE BOX H

NOTES:

** Amplifier gain changed from 100 to 50 on 10-10-90

ACAD FILE: TRIP206.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 7 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF TRIP10
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	AMPLIFIER CH NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	FILTER NO	FREQ	GAIN	CAL VOID DATE	SYSTEM A0 (E.U.)	A1 (E.U./VOLT)	ENGR. UNITS	RECORDER CH. NO.	SENS (E.U./DIV.)	COMMENTS
LTV2	60	60	LTHD V2	Columbia SA-101-HP	1519	1561 mv/G	X = 900 Y = -39.5 Z = 14		K	30 V	50 FIX		11.07 V			15 Hz				0.0191 G/v	G			MLC BOX A RT SIDE LTHD VERT TRK-1
LTL1	61	61	LTHDL1	Columbia SA-101-HP	1517	1565 mv/G	X = 900 Y = -39.5 Z = 14		K	30 V	50 FIX		10.96 V			15 Hz				0.0191 G/v	G			MLC LTHD BOX A LAT TRK-1 RT SIDE
AZ4	62	62	AZ4C	ENDEVCO 7290	AE 37	198.1 MV/G	X = 1000 Y = 0 Z = 58.5	10-10-90	K	15 V	2 FIX	VSUB	3.320 V			120 Hz	1			2.524 G/V	G			MLC ACCEL-VERT ABOVE SPAN BLST 1
AY4	63	63	AY4C	ENDEVCO 7290	AH 71	197.2 MV/G	X = 1000 Y = 1 Z = 58.5	6-26-91	K	15 V	2 FIX	VSUB	3.327 V			120 Hz	1			2.535 G/V	G			MLC ACCEL LAT ABOVE SPAN BLST 1
AX3	64	64	AX3C	ENDEVCO 7290	AE 38	198.7 MV/G	X = 1001 Y = 1 Z = 58.5	10-10-90	K	15 V	2 FIX	VSUB	3.323 V			120 Hz	1			2.516 G/V	G			MLC ACCEL LONG ABOVE SPAN BLST 1
JBX3	65	65	JBX 003A	HUMPREY	119	4.071 DEG/V	X = 1895 Y = 0 Z = 58	2-17-91	K	10 V	1 FIX	VSUB				15 Hz	1			1.018 DEG/V	DEG			MLC A-END CARBODY ROLL ANGLE
DBX3	66	66	DBX 003A	CELESCO	A 45651	0.4721 V/IN	X = 1895 Y = 18 Z = 41	4-23-91	K	10 V	1 FIX	VSUB				15 Hz	1			2.118 IN/V	INCH			MLC COUPLER ANGLE A-END LF
DBX4	67	67	DBX 004A	CELESCO	A 45653	0.4733 V/IN	X = 1895 Y = -18 Z = 41	5-30-91	K	10 V	1 FIX	VSUB				15 Hz	1			2.113 IN/V	INCH			MLC COUPLER ANGLE A-END RT
IC2	68	68	IC TC2	MINOR	VKP 3-1	0.6732 mv/V	X = 1918 Y = 0 Z = 34	5-17-91	HI	10 V	VAR	442 K	87.951 KIPS -4.397 VDC			15 Hz	1			20 KIPS/V	KIPS			MLC A-END INSTRUMENTED COUPLER
AZ5	69	69	AZ5C	ENDEVCO 7290	AE 42	198.1 MV/G	X = 1375 Y = -30 Z = 58.1	10-10-90	K	15 V	2 FIX	VSUB	3.315 V			120 Hz	1			2.524 G/V	G			MLC CTR FLOOR ACCEL VERT CAR

NOTES:

ACAD FILE: TRIP207.DWG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 8 OF ___

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE ______ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ______
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ______ SET-UP FILE
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ______ MIF TRIP10

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC.-L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO	FREQ.	GAIN	CAL VOID DATE	A0 (E.U.)	A1 (E.U./VOLT)	ENGR UNITS	CH NO.	SENS. (E.U./DIV.)	
AZ6	70	70	AZ6C	ENDEVCO 7290	AE 48	208.2 MV/G	X= 1744 Y= 0 Z= 58.1	10-10-90	K	15 V	2 FIX	VSUB	3.339 V			120 Hz	1			2.402 G/V	G			ACCEL VERT ABOVE SPAN BLST 2 MLC
AY5	71	71	AY5C	ENDEVCO 7290	AE 49	199.6 MV/G	X= 1372 Y= -30 Z= 58.1	10-10-90	K	15 V	2 FIX	VSUB	3.334 V			120 Hz	1			2.505 G/V	G			ACCEL LAT CAR CTR FLOOR MLC
AY6	72	72	AY6C	ENDEVCO 7290	AC 97	203.2 MV/G	X= 1744 Y= 1 Z= 58.1	11-6-90	K	15 V	2 FIX	VSUB	3.331 V			120 Hz	1			2.461 G/V	G			ACCEL LAT ABOVE SPAN BOLSTER 2 MLC
AX4	73	73	AX4C	ENDEVCO 7290	AJ 02	198.3 MV/G	X= 1745 Y= 0 Z= 58.1	6-26-91	K	15 V	2 FIX	VSUB	3.340 V			15 Hz	1			2.521 G/V	G			ACCEL LONG ABOVE SPAN BLST 2 MLC
DBX5	74	74	DBX5	CELESCO	A 45611		X= 1072 Y= 92.5 Z= 36.5	3-7-91	K	10 V	2 FIX	VSUB				15 HZ				.802 IN/V	IN			DISPLACEMENT SPAN BLST-1 TO CARBODY MLC B-END
JBX4	75	75	JBX 004A	NORTHROP	102	3.819 DEG/V	X= Y= Z=	10-26-90	K	28 V	2 FIX	VSUB				15 Hz	1			0.955 DEG/V	DEG			CARBODY ROLL ANGLE B-END CAR-3
AZ7	76	76	AZ7E	ENDEVCO 7290	AG 60	197.0 MV/G	X= Y= Z=	6-26-91	K	15 V	2 FIX	VSUB	3.330 V			15 Hz	1			2.538 G/V	G			ACCEL VERT ABOVE SPAN BLST 1 CAR-3
AZ8	77	77	AZ8E	ENDEVCO 7290	AK 18	196.1 MV/G	X= Y= Z=	6-27-91	K	15 V	2 FIX	VSUB	3.333 V			15 Hz	1			2.549 G/V	G			ACCEL VERT ABOVE SPAN BLST 2 CAR-3
AY7	78	78	AY7E	ENDEVCO 7290	AK 29	204.8 MV/G	X= Y= Z=	6-27-91	K	15 V	2 FIX	VSUB	3.322 V			15 Hz	1			2.441 G/V	G			ACCEL LAT ABOVE SPAN BLST 1 CAR-3
AY8	79	79	AY8E	ENDEVCO 7290	AK 31	197.5 MV/G	X= Y= Z=	6-27-91	K	15 V	2 FIX	VSUB	3.339 V			15 Hz	1			2.532 G/V	G			ACCEL LAT ABOVE SPAN BLST 2 CAR-3

NOTES:

ACAD FILE: TRIP208.DVG

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 9 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________ MIF TRIP10

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC-L/R	GAIN FIX/VAR	R-CAL RES	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ.	GAIN	CAL VOID DATE	AO (E.U.)	AI (E.U./VOLT)	ENGR. UNITS	CH. NO	SENS. (E.U./DIV.)	
AX5	80	80	AX5E	ENDEVCO 7290	AH 57	197.2 MV/G	X= Y= Z=	6-26-91	K	15 V	2 FIX	VSUB	3.325 V			15 Hz	1			2.535 G/V	G			ACCEL LONG ABOVE SPAN BLST 1 CAR-3
AX6	81	81	AX6E	ENDEVCO 7290	AK 37	196.8 MV/G	X= Y= Z=	6-27-91	K	15 V	2 FIX	VSUB	3.334 V			15 Hz	1			2.541 G/V	G			ACCEL LONG ABOVE SPAN BLST. 2 CAR-3
SP4	82	82					X= Y= Z=																	SPARE
IRIG	83	83	IRIG-B				X= Y= Z=													1				IRIG-B DIGITAL INTERFACE
LTV3	84	84	LTHD V3	Columbia SA-101-HP	1516	1561 mv/G	X= Y= Z=		K	30 V	50 ** FIX		11.027 V			15 HZ				0.0192 G/v	G			LTHD-2 VERT BOX-1 TRK-3 CAR-2 LF SIDE
LTV4	85	85	LTHD V4	Columbia SA-101-HP	1526	1554 mv/G	X= Y= Z=		K	30 V	50 ** FIX		10.966 V			15 HZ				0.0193 G/v	G			LTHD-2 VERT BOX-B TRK-3 CAR-2 RT SIDE
LTL2	86	86	LTHD L2	Columbia SA-101-HP	1527	1552 mv/G	X= Y= Z=		K	30 V	50 ** FIX		11.014 V			15 HZ				0.0190 G/v	G			LTHD-2 BOX-B TRK-3 CAR-2 RT SIDE
SP5	87	87					X= Y= Z=																	
JBR1	88	88	JBX 001R	Humphrey	111	20°/s	X= Y= Z=	2-17-91	K	10 V	1 FIX	VSUB				15 Hz				4.05°/S	DEG.			CARBODY ROLL ANGLE CAR-1 A-END RAW
JBR2	89	89	JBY 002A	Humphrey	118	20°/s	X= Y= Z=	2-17-91	K	10 V	1 FIX	VSUB				15 Hz				4.05°/S	DEG.			CARBODY ROLL ANGLE MLC B-END RAW

NOTES:

ACAD FILE: TRIP209.DWG

** AMPLIFIER GAIN CHANGED FROM 100 TO 50 ON 10-10-90

PEACEKEEPER RAIL GARRISON
TEST CONFIGURATION DATA SHEET

PAGE 10 OF ____

TEST NAME TRIPLET ON-TRACK TEST PHASE II DATE ________ W.O. 87593 LOC. CHAP XI TRACK CONDITIONS
INSTR. ENGR./TECH. STARKWEATHER TEST ENGR. ERIC BIER QA ________
SOFTWARE/VERSION xCONTAQ8BB RECORDER I.D. NO. ________ SET-UP FILE MIF_TRIP10
SAMPLE RATE 512 ENCODER/DIGITIZER I.D. NO. ________

INST INIT	DAS CH	PP CH	MEAS. CODE	TRANSDUCER					AMPLIFIER						FILTER				SYSTEM			RECORDER		COMMENTS
				MFG.	S.N.	SENS.	LOC.	CAL VOID DATE	CH. NO.	EXC. L/R	GAIN FIX/VAR	R-CAL RES.	CAL. E.U. & VOLTS	S.N. CAL VOID DATE	NO.	FREQ	GAIN	CAL VOID DATE	AO (E.U.)	AI (E.U./VOLT)	ENGR. UNITS	CH. NO.	SENS. (E.U./DIV.)	
JBR3	90	90	JBX 003R	HUMPHREY	119	20°/S	X= Y= Z=	2-17-91	K	10 V	1 FIX		VSUB			15 Hz				4.05 DEG/S	DEG			CARBODY ROLL ANGLE MLC A-END RAW
JBR4	91	91	JBY 004R	NORTHROP	102	40°/S	X= Y= Z=	10-26-90	K	28 V	2 FIX		VSUB			15 Hz				4.05 DEG/S	DEG			CARBODY ROLL ANGLE CAR-3 B-END RAW
HV1R	92	92		COLUMBIA SA-101-HP	1513	1555 mv/s	X= Y= Z=	1-19-91	K	30 V	50 FIX		10.913 V			15 Hz				.643 G/V	G			MLC LTHD VERT TRK-1 BOX RAW
HV2R	93	93		COLUMBIA SA-101-HP	1519	1561 mv/s	X= Y= Z=	1-24-91	K	30 V	50 FIX		11.07 V			15 Hz				.641 G/V	G			MLC LTHD VERT TRK-1 BOX RAW
HL1R	94	94		COLUMBIA SA-101-HP	1517	1565 mv/s	X= Y= Z=	1-23-91	K	30 V	50 FIX		10.96 V			15 Hz				.639 G/V	G			MLC LTHD LAT TRK-1 BOX RAW
HV3R	95	95		COLUMBIA SA-101-HP	1516	1561 mv/s	X= Y= Z=	1-19-91	K	30 V	50 FIX		11.027 V			15 Hz				.641 G/V	G			MLC LTHD VERT TRK-3 BOX RAW
HV4R	96	96		COLUMBIA SA-101-HP	1526	1554 mv/s	X= Y= Z=	1-24-91	K	30 V	50 FIX		10.966 V			15 Hz				.644 G/V	G			MLC LTHD VERT TRK-3 BOX RAW
HL2R	97	97		COLUMBIA SA-101-HP	1527	1552 mv/s	X= Y= Z=	1-24-91	K	30 V	50 FIX		11.014 V			15 Hz				.644 G/V	G			MLC LTHD LAT TRK-3 BOX RAW
							X= Y= Z=																	
							X= Y= Z=																	

NOTES:

ACAD FILE: TRIP210.DWG

APPENDIX D

IITRI WHEEL SET INSTRUMENTATION, CALIBRATION, AND OPERATION PROCEDURES

(1) IITRI 36-INCH INSTRUMENTATION WHEEL SET
(2) IITRI 38-INCH INSTRUMENTATION WHEEL SET
(1) ENSCO 38-INCH INSTRUMENTATION WHEEL SET

(1)

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-3500
INSTALLATION, CALIBRATION AND OPERATION OF IITRI 36 INCH INSTRUMENTED WHEEL SETS

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-3500
INSTALLATION, CALIBRATION AND OPERATION OF IITRI 36 INCH INSTRUMENTED WHEEL SETS

1.0 DESCRIPTION

The purpose of this procedure is to outline the sequence of steps to be taken for the installation, calibration and operation of the IITRI 36-Inch Instrumented Wheel Sets.

1.1 INDEX

1.2 EQUIPMENT LIST

a.	4 ea.	IITRI 36-inch Instrumented Wheel Sets
b.	4 ea.	Junction Boxes with 13 Ecton Signal Conditioners
c.	8 ea.	25-foot Wheel Set to Junction Box Cables
d.	8 ea.	Slip Rings with Vibration Gaskets
e.	4 ea.	Input Patch Panels
f.	1 ea.	Calibration Panel and Power Supply.
g.	4 ea.	Wheel Set Processor Units
h.	4 ea.	Operational Control Panel
i.	4 ea.	Keyboard Drawer Units

1.3 FIGURE LIST

1.4 TABLE LIST

None

1.5 REFERENCE LIST

Instrumented railroad wheel/axle systems, design, operation and calibration report. IITRI project E06607.

Instrumented railroad wheel/axle system, wheel analyzer description, operation and software report. IITRI project E06607.

ECTRON Operations Manual

M1001 Manual Of Standards and Recommend Practices, C, Part II, Volume I, Chapter XI

TTC Operation Rules for the Transportation Test Center, Pueblo, Colorado, AAR, November 1, 1989

Peacekeeper Rail Garrison Test Implementation Plan, (for appropriate test car), Chapter XI testing

NOTE

All personnel involved in the performance of this procedure or observing the test(s) will comply with the TTC Safety Rule Book

2.0 INSTALLATION OF EQUIPMENT

2.1 Installation of Instrumented Wheel Sets

TASK NUMBER	PROCEDURE	QA INITIAL
2.1.1	Refer to the Test Measurement List (PKRG-7000) and determine the placement of the instrumented wheel sets.	
2.1.2	Remove the trucks containing the wheel sets to be swapped from the test vehicle.	
2.1.3	Swap the original wheel sets with the instrumented wheel sets using standard bearing adapters. Refer to Figure 2-1 in the PKRG-7000-FC Procedure.	

NOTE

For convention, the A-end of the wheel set should be placed on the left side of the vehicle. Left is defined while standing on the ground facing the B-end of the vehicle.

2.1.4	Replace the trucks back underneath the test vehicle, but **DO NOT CONNECT THE BRAKE RIGGING.** Tie up the brake rigging to ensure it is not rubbing on the axles. This could cause damage to the torque circuits.	
2.1.5	Quality verify installation of wheel sets is completed.	______

2.2 Installation of Slip Rings

TASK NUMBER	PROCEDURE	QA INITIAL
2.2.1	Each wheel of the instrumented wheel set provides for the attachment of a slip ring to a specially machined end cap.	
2.2.2	Carefully pull the connector out of the wheel a few inches.	
2.2.3	Slip a rubber vibration gasket over the cable.	
2.2.4	Attach the wheel connector to the slip ring.	
2.2.5	Using the 6-32 cap screws with machined throats, attach the slip ring and vibration gasket to the wheel set. The cap screws should be snugged up, and then another one-half turn applied. This puts even pressure on the vibration gasket.	
2.2.6	Using steel wire, place the wire through the heads of the cap screws forming a ring around the slip ring. Pig tail the two ends of the wire together using pliers.	
2.2.7	Quality verify installation of slip rings is complete.	________

2.3 Vehicle Coupling

TASK NUMBER	PROCEDURE	QA INITIAL
2.3.1	Couple test vehicle, buffer car, and locomotive to the Dot X 205 Rail Test Vehicle as illustrated in Figure 2-2 PKRG-7000. Comply with TTC operating rules.	_______

2.4 Installation of Junction Boxes

TASK NUMBER	PROCEDURE	QA INITIAL
2.4.1	The junction boxes can be mounted at any appropriate location, but must be within 25 feet of the wheels to accommodate the interconnecting cable. The J-Box should be mounted with the connectors pointing in a direction for easy access.	

2.5 Interconnection of the System

TASK NUMBER	PROCEDURE	QA INITIAL
2.5.1	Refer to Figure 2-1 Block Diagram of Instrumented Wheel Set System, and Figure 2-2 Communication Cable Array, to complete connection of appropriate cable arrays.	

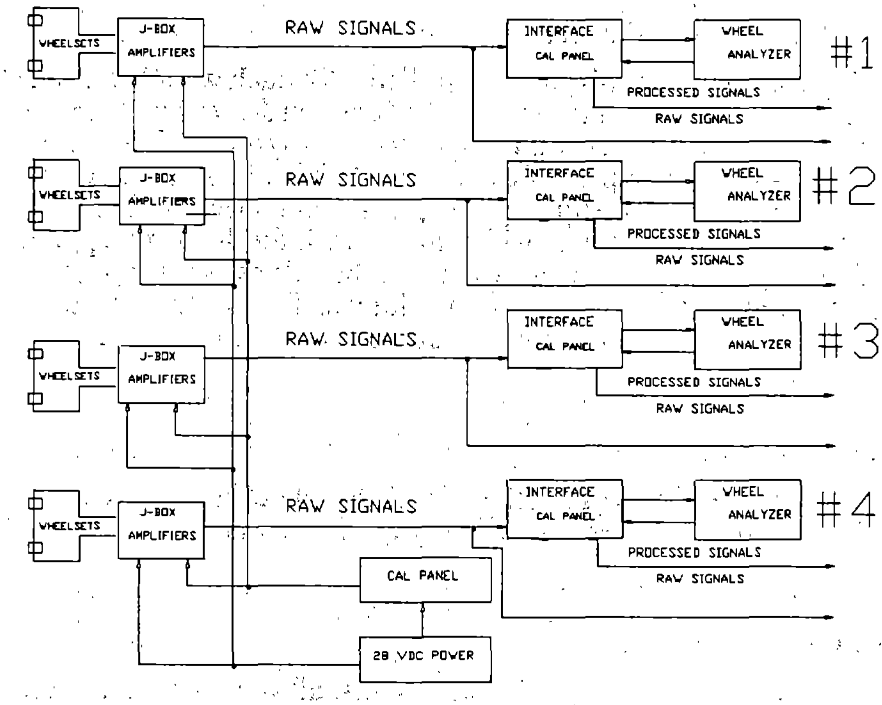

Figure 2-1 Block Diagram of Instrumented Wheel Set

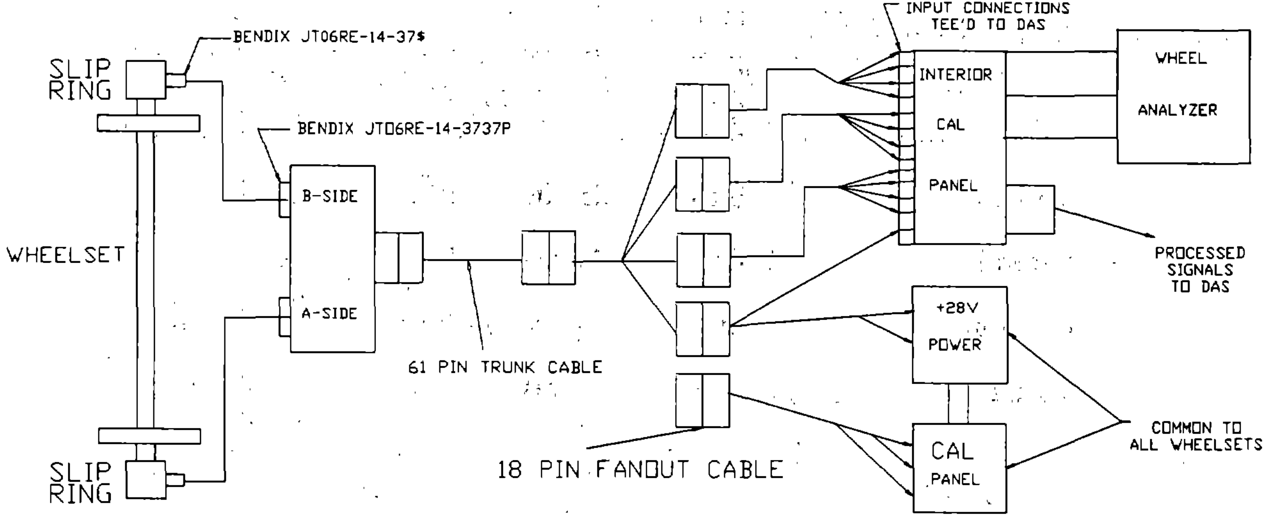

Figure 2-2 Communication Cable Connections (Typical for each Wheel Set)

2.5.2 Slip Ring Transmission Cables:

Two slip ring transmission cables are supplied with each wheel set. The cable is used to connect the slip rings to the junction J-box which, in turn, is connected to the data acquisition and processing system. The cable is Belden Type 9544 with a slip Bendix Type JTO6RE-14-375 connector at one end, which mates to the slip ring receptacle, and a Bendix Type JT06RE-14-37P at the other end, which mates with the J-box receptacle. Connect the slip rings and J-boxes by routing the cables away from any moving parts. Secure using tie wraps and clamps. Ensure that service loops are provided between the trucks, span bolster and car body.

2.5.3 Systems Connections:

Figure 2-2 shows the cable connections from the wheel sets to the J-boxes and on to the inside of the test car to the processor and calibration panel.

2.5.4 Signal Conditioner Setup:

When initially setting up the signal conditioners, all weight must be taken off the instrumented wheel sets so that no imbalance will occur during operation. This can be accomplished by jacking up the wheel sets so that they are free to rotate. Refer to the instruction manual for the ECTRON amplifier, Section 1.5.3, for operation of the signal conditioners. Ensure the setup of the amplifier is as follows:

BRIDGE CIRCUIT	SHUNT RESISTOR	EXCITATION VOLTAGE	GAIN SETTING
Vertical	681k ohms	25.00v+/- 10mV	1K Fixed
Lateral	118K ohms	20.00v+/- 10mV	200 Fixed
Position	825k ohms	20.00v+/- 10mV	1K Fixed
Torque	442k ohms	10.00V+/- 10mV	1K Fixed

3.0 CALIBRATION OF WHEEL SETS

TASK NUMBER	PROCEDURE	QA INITIAL

3.1 With the wheel sets lifted, balance the amplifiers to zero +/- 10 mV. Place the selector switch in the +CAL and -CAL positions. The expected outputs listed below are approximate and can be used for a system check.

BRIDGE CIRCUIT	SHUNT CAL VOLTAGE
Vertical	+1.985
Lateral	+7.651
Position	+1.095
Torque	+2.980

3.1.2 After calibration is complete at the remote J-box, place the CAL selector switch of the amplifiers in the REMOTE position.

3.1.3 Using the cal panel inside the test vehicle, place the CAL switch in the ON position and toggle the + and - switch back and forth while monitoring the raw channels on the data acquisition terminal. The CAL voltages should be similar to those observed outside at the amplifier.

3.1.4 Place the CAL switch in the OFF position.

3.1.5 After all calibrations have been verified inside the car, close and secure the amplifier and J-box covers.

3.1.6 Calibration of the system is performed during daily operation; therefore, no special system calibration is necessary during installation.

3.1.7 Quality verify calibration of wheel set system. ______

4.0 DAILY OPERATIONS

4.1 Signal Conditioning Verification

TASK NUMBER	PROCEDURE	QA INITIAL
4.1.1	While monitoring the wheel sets raw channels on the Data Acquisition Terminal, place the CAL switch to the ON position. Toggle the + and - switch on the cal panel back and forth. The voltage difference between + and - cals should be approximately the same as in Section 3.1.	
4.1.2	Quality verify signal conditioning setup is complete.	______

5.0 WHEEL ANALYZER OPERATION

5.1 Start-Up

TASK NUMBER	PROCEDURE	QA INITIAL
5.1.1	Daily start-up of the wheel analyzer system consists of inserting the 3.5-inch program floppy disk into the computer system's floppy disk and then applying AC power to the computer system. The computer system will then execute its internal ROM-based diagnostics, and upon successful completion, attempt to load the necessary programs from the floppy disk. Should the floppy disk not be installed, the computer will write an error message to the monitor. Once the floppy disk is inserted in the disk drive, the loading can continue by depressing any key on the keyboard.	
5.1.2	The computer system first loads the MS-DOS operating system. It then loads the AUTOEXEC.BAT command file. This file contains a series of commands that are executed automatically without user interaction. A series of screens will appear, pausing with the menu screen. The menu screen presents the option of loading/running the program for either wheel set WS-19 or WS-20. Depending upon which wheel set is connected to the wheel analyzer, the user must select the corresponding program. This is done by depressing the 1 key for WS-19 or the 2 key for WS-20 on the computer's keyboard. Note depressing any other key will	

have no function and the computer will respond with a BEEP; furthermore, the correct program must be loaded, otherwise the wheel analyzer's output data will be meaningless.

5.1.3 Upon selecting the desired wheel analyzer program the computer will copy the respective program from the floppy disk to a "virtual" disk created in memory. This "virtual" disk is not a physical disk and only exists in the software, hence its name "virtual". The program will remain on the virtual disk until AC power is lost or the computer is rebooted. After the respective wheel analyzer program is copied, the monitor's screen is cleared and two messages are written to the screen. The first message states the floppy disk can now be removed. The floppy only needs to be re-inserted if the computer is to be rebooted. The second message confirms which wheel program was loaded.

5.1.4 From this point on, the computer is running the selected wheel analyzer program. As described earlier, the wheel analyzer will be in the HOLD mode and control of the wheel analyzer is via the push buttons on the control panel. The keyboard is no longer needed and can be stored in its drawer.

5.1.5 The wheel analyzer also has a program that "blanks" or turns off the monitor's screen automatically after 3 minutes of no keyboard or screen activity. The purpose of this feature is to prevent images left on the screen from extended periods, from being "burned" into the screen's CRT. The screen blanking program runs simultaneously along with the wheel analyzer program with negligible performance degradation. The screen will "blank" after 3 minutes of either no keystrokes or writing to the screen by the wheel analyzer program. As a result, once the wheel analyzer program has been running, and the above conditions have been met, the monitor will "blank" itself. Upon either the program writing to the screen or a key being depressed, the monitor will turn on and the 3 minute time out counter will be reinitiated. It is suggested that should it be necessary to determine if the wheel analyzer program is running, that either the CTRL key or the current analyzer's mode push button be depressed. While instigating either of these actions, monitor for any status messages.

5.1.6 Once the wheel analyzer program is running, it continues executing until either the computer is rebooted or a program software error is encountered. Rebooting the computer is performed via the computer's front panel RESET push button or by depressing the CTRL and ALT and DEL keys simultaneously on the computer's keyboard. Rebooting the computer requires the floppy disk to be reinserted into the disk drive.

5.1.7 Should the program encounter a software error, the wheel analyzer program will stop executing, and an error message will be written to the screen. This error message should be copied for diagnosis. A message will also appear on the screen prompting the user to depress any key on the keyboard to restart the wheel analyzer program. Note, the floppy disk is not needed to restart the program with this method. In the unlikely event that depressing a key does not restart the program, it may be necessary to manually restart the program. This is accomplished by typing the command IITRI followed by the RETURN key on the keyboard.

5.1.8 Quality verify wheel analyzer is completed. ______

5.2 Wheel Analyzer Calibration

TASK NUMBER **PROCEDURE** **QA INITIAL**

5.2.1 In order to ensure the wheel analyzer contains the necessary calibrations for each channel, the control panel is used to select the desired analyzer mode.

5.2.2 Calibration should be performed after verifying calibration level as outlined in Section 4.1.1. The test vehicle should be stopped on level tangent track.

5.2.3 Verify the CAL switch on the cal panel is in the OFF position. ______

5.2.4 Press the ZERO switch on the control panel for two seconds, and release.

5.2.5 Place the CAL switch on the cal panel in the ON position and the + and - switch in the + position.

5.2.6 Press the CAL switch on the appropriate control panel for two seconds and release.

5.2.7 Perform Steps 5.2.3 through 5.2.6 for each wheel set.

5.2.8 Verify the CAL switch on the cal panel is in the OFF position.

5.2.9 Quality verify wheel analyzer calibration is complete. ______

5.3 Wheel Signaling Processing

TASK NUMBER **PROCEDURE** **QA INITIAL**

5.3.1 To place the wheel analyzer mode into operation from HOLD mode, begin train operations.

5.3.2 When the speed reaches approximately 10 mph, press the RUN LOW switch. This begins calculation of a running zero.

5.3.3 After approximately 15 seconds, press the RUN HIGH switch. The analyzer will now be ready to perform testing.

NOTE

The analyzer can be used to collect data in the RUN LOW mode, but must be placed in the HOLD mode while stopped or math errors will occur, and the program will stop. If this occurs, the calibration procedures in Section 5.2 must again be performed. Also, an occasional D/A error may occur when switching to RUN LOW or RUN HIGH, this is normal and no action is required

5.3.4 Occasionally, the system should be placed in the RUN LOW mode for 15 seconds while the train is running to recalculate the running zero. This should be performed once per hour for the first few hours of operation, and then every two to three hours after that.

5.3.5 The system may be shut down at any time without damage to equipment, but will have to be rebooted upon power up. The calibration procedures in Section 5.2 will then have to be performed.

6.0 TESTING

TASK NUMBER	PROCEDURE	QA INITIAL
6.1	Perform testing as required by the vehicle test procedure.	

7.0 TEAR DOWN

TASK NUMBER	PROCEDURE	QA INITIAL
7.1.1	Remove power from all conditioners and wheel analyzers.	
7.1.2	Remove all cables and J-boxes from the test vehicle.	

272

7.1.3 Clip the wire securing the slip ring cap screws and carefully remove the slip rings by removing the cap screws, and pulling the assembly out a few inches, and finally disconnecting the slip-ring from the wheel connector. Be sure to remove and save the rubber vibration gaskets.

7.1.4 Replace the instrumented wheel sets with the original set by removing the trucks.

7.1.5 Replace the trucks and ensure all brake rigging is connected and operating properly.

7.1.6 Pack and store all wheel sets, J-Boxes, slip-rings, cables, and support hardware.

8.0 QUALITY ACCEPTANCE

TASK NUMBER	PROCEDURE	QA INITIAL
8.1	Quality verified that PKRG-3500 is complete and closed.	
8.2	Authorized QA signature______________________________.	

(2)

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-3400
INSTALLATION, CALIBRATION, AND OPERATION OF IITRI 38-INCH INSTRUMENTED WHEEL SETS

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-3400
INSTALLATION, CALIBRATION, AND OPERATION OF IITRI 38-INCH INSTRUMENTED WHEEL SETS

1.0 DESCRIPTION

The purpose of this procedure is to outline the sequence of steps to be taken for the installation, calibration, and operation of the IITRI 38-Inch Instrumented Wheel Sets.

1.1 INDEX

5.0 Wheel Analyzer Operation
6.0 Test Tear Down
7.0 Quality Verification

1.2 EQUIPMENT LIST

a.	2 ea.	IITRI 38-Inch Instrumented Wheel Sets
b.	2 ea.	Junction Boxes
c.	4 ea.	25-Foot Wheel Set to J-Box Cables
d.	4 ea.	Slip Rings with Vibration Gaskets
e.	2 ea.	Input Patch Panels
f.	26 ea.	Dynamic Signal Conditioners
g.	1 ea.	Tektronixs Rack with Calibration Panel and Power Supply.
h.	2 ea.	Wheel Set Processor Units
i.	2 ea.	Operational Control Panel
j.	2 ea.	Keyboard Drawer Units

1.3 FIGURE LIST

1.4 TABLE LIST

NONE

1.5 REFERENCE LIST

Instrumented Railroad Wheel/Axle Systems, Design, Operation and Calibration Report. IITRI project E06607

Instrumented Railroad Wheel/Axle System, Wheel Analyzer Description, Operation and Software Report. IITRI project E06607

Waugh Controls Corporation, Dynamics Electronics Division, Operations Instructions for Universal Amplifier Model 7600A

M1001 Manual Of Standards and Recommended Practices, C, Part II, Volume I, Chapter XI

TTC Operation Rules for the Transportation Test Center, Pueblo, Colorado, AAR, November 1, 1989

Peacekeeper Rail Garrison Test Implementation Plan, (for appropriate test car), Chapter XI Testing

NOTE

All personnel involved in the performance of this procedure or observing the test(s) will comply with the TTC Safety Rule Book.

2.0 INSTALLATION OF EQUIPMENT

2.1 Installation of Instrumented Wheel Sets

TASK NUMBER	PROCEDURE	QA INITIAL
2.1.1	Refer to the test measurement lists located in PKRG-3700 and determine the placement of the instrumented wheel sets.	
2.1.2	Remove the trucks containing the wheel sets to be swapped from the test vehicle.	

NOTE

Swap the original wheel sets with the instrumented wheel sets using the MLC bearing adapters.

NOTE

For convention, the A-end of the wheel set should be placed on the left side of the vehicle. Left is defined while standing on the ground at the B-end of looking towards the A-end of the vehicle.

2.1.3 Replace the trucks back underneath the test vehicle, but **DO NOT CONNECT THE BRAKE RIGGING.** Tie up the brake rigging to ensure it is not rubbing on the axles. This could cause damage to the torque circuits.

2.1.4 Quality verify installation of wheel sets is completed. ______

2.2 Installation of Slip Rings

TASK NUMBER PROCEDURE QA INITIAL

2.2.1 Each wheel of the instrumented wheel set provides for the attachment of a slip ring to a specially machined end cap.

2.2.2 Carefully pull the connector out of the wheel a few inches.

2.2.3 Slip a rubber vibration gasket over the cable.

2.2.4 Attach the wheel connector to the slip ring.

2.2.5 Using the 6-32 cap screws with machined throats, attach the slip ring and vibration gasket to the wheel set. The cap screws should be snugged up, and then another one-half turn applied. This puts even pressure on the vibration gasket.

2.2.6 Using steel wire, place the wire through the heads of the cap screws forming a ring around the slip ring. Pig tail the two ends of the wire together using pliers.

2.2.7 Quality verify installation of the slip rings is complete. ______

2.2.8 Couple test vehicle and locomotive to the Dot X 205 Rail Test Vehicle as illustrated in Figure 2-1, PKRG-3700. Comply with TTC Operating Rules. ______

2.3 Installation of Junction Boxes

TASK NUMBER	PROCEDURE	QA INITIAL
2.3.1	The junction boxes (J-boxes) can be mounted at any appropriate location, but must be within 25 feet of the wheels to accommodate the interconnecting cable. The J-box should be mounted with the connectors pointing down to avoid any water entry.	

2.4 Interconnection of the System

TASK NUMBER	PROCEDURE	QA INITIAL
2.4.1	Refer to Figure 2-1 Block Diagram of Instrumented Wheel Set System, and Figure 2-2 Communication Cable Array.	

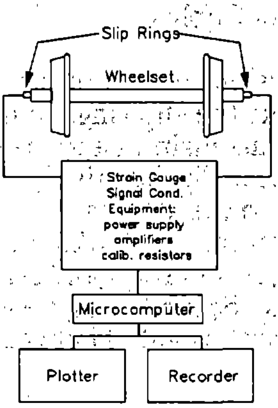

Figure 2-1 Block Diagram of Instrumented Wheel Set System

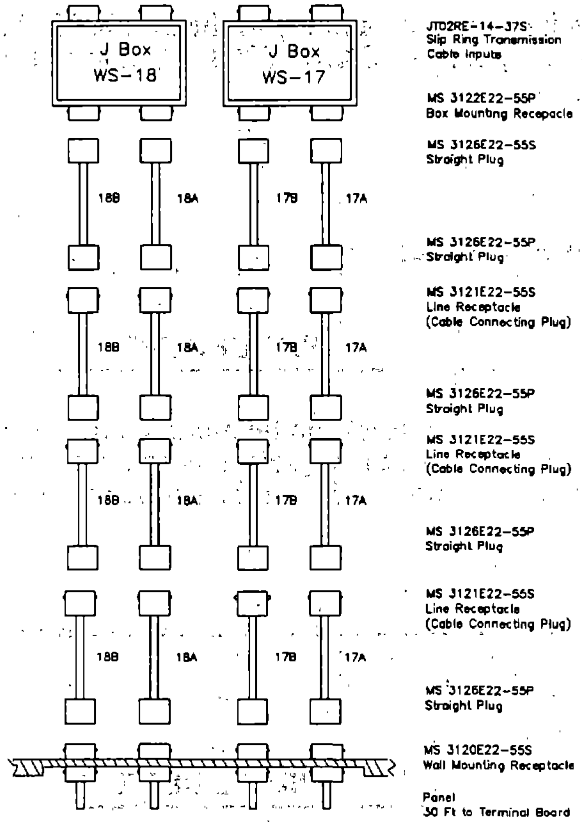

Figure 2-2 Communication Cable Array

2.4.2 Slip Ring Transmission Cables

Two slip ring transmission cables are supplied with each wheel set. The cable is used to connect the slip rings to the J-box, which in turn, is connected to the data acquisition and processing system. The cable is Belden Type 9544 with a slip Bendix Type JTO6RE-14-375 connector at one end, which mates to the slip ring receptacle, and a Bendix Type JT06RE-14-37P at the other end, which mates with the junction box receptacle. Connect the slip rings and J-boxes by routing the cables away from any moving parts. Secure using tie wraps and clamps. Ensure that 10-foot service loops are provided between the trucks, span bolster and car body.

2.4.3 Systems Connections

Figure 2-2 shows the cable connection array. Three cable configurations are shown:

Configuration	Length (ft)	Connectors	
A.	50	MS3126E22-55S Straight Plug	MS3121E22-55P Straight Plug
B.	50	MS3121E22-55S Cable Connecting Plug	MS3126E22-55P Straight Plug
C.	30	MS3120E22-55S Wall Mounting Receptacle	Open End

Starting at the J-box, connect the socket of the A cable. Continue with B cables as required, connecting the plug of the last one to the socket of the C cable attached to the interface panels.

NOTE

Allow slack in the inter-car cabling to accommodate curving.

2.4.4 Rack Connections

Connect the patch bay, signal conditioners, control panel, and the wheel set processor according to the design, operation and calibration report, *Reference 1.5.1*.

2.4.5 Quality verify interconnection of the system is completed. ______

3.0 CALIBRATION OF WHEEL SET SYSTEM

TASK NUMBER	PROCEDURE	QA INITIAL

3.0.1 A Shunt calibration check should be performed to ensure all wheel set channels are operating properly. The shunt calibration resistors, excitation voltages, and gain settings are as follows:

BRIDGE CIRCUIT	SHUNT RESISTOR	EXCITATION VOLTAGE	GAIN SETTING
Vertical	1000k ohms	25.00v+/- 10MV	1K Fixed
Lateral	511K ohms	20.00v+/- 10MV	1K Fixed
Position	787k ohms	20.00v+/- 10MV	1K Fixed
Torque	549k ohms	10.00V+/- 10MV	1K Fixed

3.0.2 Perform a shunt calibration on each channel by first balancing each channel and then pressing the calibration switches marked 17 and 18 on the tektronixs panel, while monitoring the output. The expected outputs listed below are approximate and can be used for a system check.

BRIDGE CIRCUIT	SHUNT CAL VOLTAGE
Vertical	+/ 2.25V
Lateral	+/ 2.37V
Position	+/ 1.54V
Torque	+/ 1.61v

3.0.3 Calibration of the system is performed during daily operation; therefore, no special system calibration is necessary during installation.

3.0.4 Quality verify calibration of wheel set system. ______

283

4.0 DAILY OPERATIONS

4.1 Signal Conditioning Setup

TASK NUMBER	PROCEDURE	QA INITIAL
4.1.1	Using a voltmeter, monitor the excitation voltages of all conditioners and set according to Section 3.1.1.	
4.1.2	Balance the circuits while monitoring the output and perform a shunt calibration check on all channels as outlined in Section 3.1.2.	
4.1.3	The bridge balancing in Step 3.1.2 may offset the true zero of the bridge respective to the midpoint of the amplifier operation range and may cause clipping of high dynamic signals. This is particularly true for the vertical bridges because the test vehicle may be parked at a peak bridge output position when the bridges are balanced. In order to prevent the possibility of clipping during operation, adjust the balance of the conditioners while running on tangent level track between 5 and 20 mph, such that the balance LED indicators flash symmetrically between red and green.	
4.1.4	A check can be performed by monitoring the output with an oscilloscope to ensure the signals are symmetrical around zero.	
4.1.5.	Quality verify signal conditioning setup is complete	______

5.0 WHEEL ANALYZER OPERATION

5.1 Start Up

TASK NUMBER	PROCEDURE	QA INITIAL
5.1.1	Daily start up of the wheel analyzer system consists of inserting the 3.5-inch program floppy disk into the computer system's floppy disk and then applying AC power to the computer system. The computer system will then execute its internal ROM-based diagnostics, and upon successful completion, attempt to load the necessary programs from the floppy disk. Should the floppy disk not be installed, the computer will write an error message to the monitor. Once the floppy disk is inserted in the disk drive, the loading can continue by depressing any key on the keyboard.	
5.1.2	The computer system first loads the MS-DOS operating system. It then loads the AUTOEXEC.BAT command file. This file contains a series of commands that are executed automatically without user interaction. A series of screens will appear, pausing with the menu screen. The menu screen presents the option of loading/running the program for either wheel set WS-17 or WS-18. Depending upon which wheel set is connected to the wheel analyzer, the user must select the corresponding program. This is done by depressing the 1 key for WS-17 or the 2 key for WS-18 on the computer's keyboard. Note: Depressing any other key will have no function and the computer will respond with a beep; furthermore, the correct program must be loaded, otherwise the wheel analyzer's output data will be meaningless.	
5.1.3	Upon selecting the desired wheel analyzer program , the computer will copy the respective program from the floppy disk to a virtual disk created in memory. This virtual disk is not a physical disk and only exists in the software, hence its name "virtual". The program will remain on the virtual disk until AC power is lost or the computer is re-booted. After the respective wheel analyzer program is copied, the monitor's screen is cleared and two messages are written to the screen. The first message states the floppy disk can now be removed. The floppy only needs to be re-inserted if the computer is to be re-booted. The second message confirms which wheel program was loaded.	

5.1.4 From this point on, the computer is running the selected wheel analyzer program. As described earlier the wheel analyzer will be in the "HOLD" mode and control of the wheel analyzer is via the push buttons on the control panel. The keyboard in no longer needed and can be stored in its drawer.

5.1.5 The wheel analyzer also has a program that "blanks" or turns off the monitor's screen automatically after 3 minutes of no keyboard or screen activity. The purpose of this feature is to prevent images left on the screen from extended periods, from being "burned" into the screen's "CRT". The screen blanking program runs simultaneously along with the wheel analyzer program with negligible performance degradation. The screen will "blank" after 3 minutes of either no keystrokes or writing to the screen by the wheel analyzer program. As a result, once the wheel analyzer program has been running, and the above conditions have been met, the monitor will "blank" itself. Upon either the program writing to the screen or a key being depressed, the monitor will turn on and the 3 minute time out counter will be reinitiated. It is suggested that should it be necessary to determine if the wheel analyzer program is running, that either the "CTRL" key or the current analyzer's mode push button be depressed.

5.1.6 Once the wheel analyzer program is running, it continues executing until either the computer is re-booted or a program software error is encountered. Re-booting the computer is performed via the computer's front panel "RESET" push button or by depressing the CTRL, ALT, and DEL keys simultaneously on the computer's keyboard. Re-booting the computer requires the floppy disk to be reinserted into the disk drive.

5.1.7 Should the program encounter a software error, the wheel analyzer program will stop executing, and error message will be written to the screen. This error message should be copied for diagnosis. A message will also appear on the screen prompting the user to depress any key on the keyboard to restart the wheel analyzer program. Note: The floppy disk is not needed to restart the program with this method. In the unlikely event that depressing a key does not restart the program, it may be necessary to manually restart the program. This is accomplished by typing the command IITRI followed by the RETURN key on the keyboard.

5.1.8 Quality verify wheel analyzer is completed. _______

5.2 Wheel Analyzer Calibration

TASK NUMBER	PROCEDURE	QA INITIAL
5.2.1	In order to ensure the wheel analyzer contains the necessary calibrations for each channel, the control panel is used to select the desired analyzer mode.	
5.2.2	Calibration should be performed after running on tangent track at low speed and all dynamic balancing has been performed as outlined in Sections 4.1.4 to 4.1.5. The test vehicle should be stopped on level tangent track.	
5.2.3	Press the ZERO switch on the control panel for two seconds, and release.	
5.2.4	While pressing the 17 or 18 CAL switch on the tektronix's panel, press the CAL switch on the appropriate control panel for two seconds and release.	
5.2.5	Release the 17 or 18 CAL switch on the tektronix panel.	
5.2.6	Perform Steps 5.1.3 through 5.1.5 for each wheel set.	
5.2.7	Quality verify wheel analyzer calibration is complete.	______

5.3 Wheel Signal Processing

TASK NUMBER	PROCEDURE	QA INITIAL
5.3.1	To place the wheel analyzer mode into operation from HOLD mode, begin train operations.	
5.3.2	When the speed reaches approximately 5 mph, press the RUN LOW switch. This begins calculation of a running zero.	
5.3.3	After approximately 15 seconds, press the RUN HIGH switch. The analyzer will now be ready to perform testing.	

NOTE

The analyzer can be used to collect data in the RUN LOW mode, but must be placed in the HOLD mode while stopped or else math errors will occur, and the program will stop. If this occurs, the calibration procedures in Section 4.2.2 must again be performed. Also, an occasional D/A error may occur when switching to RUN LOW or RUN HIGH. This is normal and no action is required.

5.3.4	Occasionally, the system should be placed in the RUN LOW mode for 15 seconds while the train is running to recalculate the running zero. This should be performed once per hour for the first few hours of operation, and then every two to three hours after that.	
5.3.5	The system may be shut down at any time without damage to equipment, but will have to be re-booted upon power up. The calibration procedures in Section 5.2.3 through 5.2.5 will then have to be performed.	

NOTE

At this point the instrumented wheel sets are properly installed and calibrated. All testing should be completed before tearing down the system as outlined in Section 6.0.

6.0 TEST TEAR DOWN

TASK NUMBER	PROCEDURE	QA INITIAL
6.1	Perform calibration operation as outlined in Section 3.0. Label data as Post Test Calibration.	
6.2	Remove all cables and J-boxes from the test vehicle.	
6.2.1	Clip the wire securing the slip ring cap screws and carefully remove the slip rings by removing the cap screws, carefully pulling the assembly out a few inches, and finally disconnecting the slip ring from the wheel connector. Be sure to remove and save the rubber vibration gasket.	
6.2.2	Replace the instrumented wheel sets with the original set by removing the trucks.	
6.2.3	Replace the trucks and ensure all brake rigging is connected and operating properly. Ensure original MLC bearing adaptors and texpad are placed back into service.	

NOTE

Operations to perform as in the AAR Car Manual

6.2.4 Pack and store all wheel sets, J-Boxes, slip rings, cables, and support hardware.

7.0 QUALITY VERIFICATION

TASK NUMBER	PROCEDURE	QA INITIAL
7.1	Quality verified that PKRG-3400 is complete and closed.	
7.2	Authorized QA signature______________________________.	

290

(3)

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-3300
INSTALLATION, CALIBRATION AND OPERATION OF ENSCO 38-INCH INSTRUMENTED WHEEL SETS

291

PEACEKEEPER RAIL GARRISON
PROCEDURE PKRG-3300
INSTALLATION, CALIBRATION AND OPERATION OF ENSCO 38-INCH INSTRUMENTED WHEEL SETS

1.0 DESCRIPTION

This procedure outlines the sequence of steps to be taken for the installation, calibration and operation of the ENSCO 38-inch Instrumented Wheel Sets.

1.1 INDEX

1.2 EQUIPMENT LIST

a.	2ea.	38" Instrumented Wheel Sets
b.	2ea.	ENSCO Signal Conditioning Units
c.	2ea.	ENSCO Wheel Set Processor Units
d.	2ea.	Keyboard Drawer Units
e.	2ea.	Interface Panels
f.	4ea.	Slip Rings
g.	1ea.	Digital Volt Meter
h.	4ea.	Machined Bearing Adaptors
i.	4ea.	Protection Housings
j.	2ea.	Magnet Rings
k.		All Safety Equipment As Required

1.3 FIGURE LIST

1.4 TABLE LIST

1.5 REFERENCE LIST

PRKG 2100....	Truck Inspection Procedure
PKRG 3100....	Instrument Installation Procedure
M1001........	Manual of Standards and Recommended Practices, Section C, Part II, Volume I, Chapter XI
	TTC Operation Rules for the Test Transportation Test Center, Pueblo, Colorado, AAR, November 1, 1989.
	Peacekeeper Rail Garrison Test Implementation Plan, (for appropriate test car), Chapter XI testing
	ENSCO Operating Manual
	TTC Safety Rule Book

1.6 REFERENCE DOCUMENTATION

NONE

NOTE

All personnel involved in the performance of this procedure or observing the test(s) will comply with the TTC Safety Rule Book.

2.0 INSTALLATION OF EQUIPMENT

2.1 Installation Of Instrumented Wheel Sets

TASK NUMBER	PROCEDURE	QA INITIAL
2.1.1	Refer to the Test Measurement List located in PKRG-3700 and determine the location of the wheel sets to be replaced with the Instrumented Wheel Sets.	______
2.1.2	Remove the trucks containing the wheel sets to be replaced from the test vehicle.	______
2.1.3	Replace the original wheel sets with the Instrumented wheel sets using the machined bearing adaptors supplied with the Instrumented Wheel Sets. The bearing adaptors for the A-end of the wheel sets are matched and must be used with the same wheel set in which it is labeled (wheel set 1 or 2). The B-end bearing adaptors are interchangeable.	______
2.1.4	The A-end of the wheel set should be placed on the left side of the vehicle. Left is defined when standing on the ground facing the B-end of the vehicle.	______
2.1.5	Place the trucks underneath the test vehicle, but DO NOT connect the brake rigging. Remove the brake rigging up to ensure that it is not rubbing on the axles (this could cause damage to the strain gage circuits).	

2.2 Installation Of Slip Rings and Housings

TASK NUMBER **PROCEDURE** **QA INITIAL**

2.2.1 There are two slip rings used with each axle of the Wheel/Rail Force Measurement and Processing System. The slip rings are Michigan Scientific Model # SR36.

2.2.2 The slip rings are not wired identically and the proper slip ring must be mounted on the corresponding sides. The A side of the wheel set contains the pulse encoder and therefore the slip ring with the plastic Molex connector is placed on this side. The B side has the Torque circuit and therefore the slip ring without the Molex connector is placed on this side.

NOTE

The slip rings should not be installed until the instrumented axle is installed under the test vehicle.

2.2.3 When the axles are installed under the test vehicle the bearing adapter marked one should be installed on wheel A axle one and the adapter marked two should be installed on wheel A axle two.

2.2.4 Insure texpads are installed on ENSCO bearing adaptor.

2.2.5 To attach the slip rings to the axle:

2.2.5.1 Mount the two end caps to the axle (the end caps are not interchangeable). The end caps with the 8-32 taped hole must be mounted on the A wheels with the end cap marked one mounted on axle one and the end cap marked two mounted on axle two. The other two end caps may be mounted on either axle.

NOTE

The slip rings should not be installed until the instrumented axle is installed under the test vehicle.

2.2.5.2 After the rings are mounted attach the six shock mounts (Lord #J-6984-22) to each end cap. Connect the connector in the axle to the connector on the rotor end of the slip ring and secure the slip ring to the shock mounts with the supplied hardware.

2.2.5.3 After the slip ring has been attached install the slip ring housing over the slip ring. The slip ring housing attaches to the bearing adapters. The slip ring housing marked one should be attached to wheel A axle one and the housing marked two should be attached to wheel A axle two. The other housings may be mounted on either axle.

2.2.5.4 On the A wheel connect the Hall-effect switch connector to the slip ring output connector. Adjust the Hall-effect switch for a gap of 1/8-inch to the magnet. Adjust the angular orientation of the Hall-effect switch so that it is directly over the rotating magnet with the wheel contacting the rail at 97.5 degrees (between the 90-degree and the 105-degree marks stamped on the side if the wheel).

2.2.5.5 Attach the slip ring output connector to the slip ring housing and attach the housing cover to the slip ring housing. **DO NOT USE RTV TO WEATHER PROOF THE HOUSING.** Use micro-measurements M-COAT B or 3M weather stripping adhesive available at auto parts stores.

CAUTION

Prolonged exposure to RTV fumes, even from cured electronic grade RTV will ruin the contact surface between the slip ring brushes and the rotor.

2.2.5.6 Install the cover for the Hall-effect switch on the slip ring housing (wheel A only). Use the rubber gasket supplied.

2.2.5.7 Quality verify that the installation of the slip rings and housings is complete.

2.3 Inter-connection of the System

TASK NUMBER	PROCEDURE	QA INITIAL

NOTE

To complete the following steps refer to
Figure 2-2 drawing #1979-B-2510

2.3.1 There are two cables that connect the Signal Conditioning Unit with each wheel. One of these cables is 140 feet long and the other is 100 feet long. The 140-foot cable must be used since this cable connects to the SCU. The 100-foot cable is an extension cable and should only be used if a cable length of greater than 140 feet is needed. Each of the 100-foot cables are identical.

NOTE

Allow enough slack in the Inter Car Cables
to accommodate curving.

2.3.2 The cables are labeled as follows

AXLE/WHEEL	140 FT. CABLE	100 FT. CABLE
1A	W1A1	W1A2
1B	W1B1	W1B2
2A	W2A1	W2A2
2B	W2B1	W2B2

2.3.3 There is one cable that connects the SCU and the computer. This cable is labeled as follows:

AXLE/WHEEL	CABLE
1	W1-3
2	W2-3

2.3.4 There are two cables for each system's output. They are connected as follows:

AXLE/WHEEL		CABLE
1A	<--->	W1-4
1B	<--->	W1-5
2A	<--->	W2-4
2B	<--->	W2-5

2.3.5 Quality verify that the inter-connection is complete. ______

3.0 SYSTEM CALIBRATION

3.1 Shunt Calibration

TASK NUMBER	PROCEDURE	QA INITIAL
3.1.1	The calculated calibration voltages must be modified to take into account the cabling from the bridges to the amplifiers. If at any time the cable lengths are either lengthened or shortened this procedure must be performed; furthermore, it must be performed to establish the reference calibration voltages at the amplifiers during the original installation. This procedure is also useful to confirm the proper operation of the system.	
3.1.2	Connect a break-out box between the slip ring connector and the cable going to the instrumentation.	

NOTE

Establish communications between personnel inside and outside the instrumentation vehicle.

3.1.3 Connect a volt meter between +P and -P on the break-out box. Adjust R8 on the corresponding board for 11.00 +/− .05 volts at the break-out box. ______

3.1.4 Record the voltage measured between TP1 and TP4 and on the corresponding board. ______

3.1.5 Voltages for daily use are listed in Table 3-1 and 3-2. ______

3.1.6 Repeat Steps 3.1.3 through 3.1.5 for all channels. ______

3.1.7 Connect a volt meter between T3 [F1] and T4 [G] on the front of the board. Adjust R2 [BL] for 0.00 +/- 0.01 volts DC. This adjustment compensates for the bridge unbalance. ______

3.1.8 The calibration resistors on the 11 string gage conditioner boards are as follows:

BOARD	CALIBRATION RESISTOR OHMS
Vab	249,000
Vc	349,650
L	87,150
T	499,000

These values will be used in the following step.

3.1.9 Connect a volt meter between T3 [FI] and T4 [G]. Connect the appropriate calibration resistor (see Step 3.1.7) between the +P and +S terminals on the break out box, and adjust R7 [G] for the voltages given in Table 3-3 and 3-4. ______

3.1.10 Remove the calibration resistor from the break out box. Switch SW1 down (switching in the calibration resistor on the board) and record this voltage in the table in Step 3.1.7 as the reference calibration voltages at the amplifier. ______

3.1.11 Repeat Steps 3.1.7 through 3.1.10 for all channels.

4.0 DAILY OPERATIONS

4.1 Signal Conditioning Calibration

TASK NUMBER	PROCEDURE	QA INITIAL
4.1.1	Connect a volt meter between T1 [+P] and T4 [G] on the front of the board. Adjust R8 [+P] for the voltages (+ / - .05 volts) in the bridge execution list in Table 4-1.	________
4.1.2	Ensure that the Table for the length of cable is being used.	________
4.1.3	If the cable lengths have changed due to a change in the configuration of the consist length after the initial setup, perform the Shunt Calibration in Section 3.0 and create new excitation and gain calibration tables.	
4.1.4	Connect a volt meter between T3 [F1] and T4 [G] on the front of the board. Adjust R2 [BL] for 0.00 + / - 0.01 volts DC. This adjustment compensates for the bridge unbalance.	________
4.1.5	Connect a volt meter between T2 [0] and T4 [G] on the front of the board. Adjust R16 [O/S] for 0.00 + / - 0.01 volts DC. This adjustment sets the output offset.	________
4.1.6	Connect a volt meter between T2 [0] and T4 [G]. Switch SW1 down [switching in the calibration resistor] and adjust R7 [G] for the shunted wheel shunt voltages given in the gain calibration list Table 4-2. Be sure to use the table for the length of cable being used.	________
4.1.7	Switch SW1 up [switching out the calibration resistor].	
4.1.8	Repeat Steps 4.1.1 through 4.1.7 for all nine bridge channels.	________

4.1.9 A waiting period of approximately 30 seconds after switching out the calibration resistor is needed before the channel has valid data. This period insures the high pass filter has settled from the square wave impulse produced by the calibration signal.

4.1.10 The bridge balancing in Step 4.1.4 may offset the true zero of the bridge relative to the midpoint of the amplifier operation range enough to cause clipping of the high dynamic signals. This is particularly true for the vertical bridges, because, the car can be parked at a peak bridge output position with a high wheel load when the bridges are balanced. In order to prevent the possibility of clipping, view the DC voltage between T3 [F1] and T4 [G] with the car moving and adjust R2 [BL] to 0 volts +/- 1.0 volt DC. This adjustment does not effect the running zero because it is maintained by the high pass filters. _______

4.1.11 Do not perform Step 4.1.10 on the torque bridge. There are two ways to get a zero reference for the torque bridge. The first is to lift one wheel. The second is to stop on level tangent track and note the torque output, then back up and stop again. The average of the two levels will estimate true zero. _______

4.1.12 Quality verify that the signal conditioning calibration is complete. _______

4.2 Computer Operations

TASK NUMBER	PROCEDURE	QA INITIAL
4.2.1	Boot the computer using the hard disc (drive C:). To use the executable version type CD TEST, this changes the directory to test; next, type WH1_C2MA for wheel set 1 or WH2_C2MA for wheel set 2. The following prompt will appear on the screen: WEST WH1****PROGRAM FOR REAL TIME WHEEL SET PROCESSING @ 300HZ AXLE 1 This program samples the wheel set bridges, torque bridge and rotational reference pulses, as amplified analog voltages. It processes the raw signals in real time and outputs analog voltages representing the vertical and lateral wheel forces, the force ratios and the axle torque forces. You may view the I/O channel assignments and generate calibration signals within the program before starting data collection.	

Pressing the F1 key will start data collection, and pressing the F2 key will exit to DOS> Pressing the F10 key halts data collection in the idle mode and displays current a/d inputs.

Do you wish to see the channel assignments? (Y or N)

4.2.2 If a daily check of amplifier zeros and gains has already been performed according to the Operation and Maintenance Manual, Press "N" then the function key F1 to start processing. If the program must be exited for any reason press F1 then F2. If this is the initial daily set-up, the volt meter function of the program may be used to assist in checking the amplifier gains. Press F10 to enter the volt meter mode and refer to the Ensco Operations Manual, Appendix A for more detailed operation.

4.2.3 Pressing F1 starts processing and displays the following prompt:

AXLE 1 DATA COLLECTION UNDER WAY; *PRESS F2* TO EXIT TO DOS

PRESS F10 TO STOP DATA COLLECTION AND VIEW A/D INPUTS

4.2.4 The vehicle must be moving at least 10 mph for oscillating bridge signals to avoid attenuation by the high pass zeroing filters; furthermore, it requires several wheel revolutions for the freshly booted program to establish the correct flange clearance correction factors and the sign of the lateral force. At this point, data collection is under way with the correctly scaled analog output voltage at the rear panel connectors. The computer makes a clicking sound to indicate that the program is operating properly. The clicking sound increases with respect to speed. The vehicle must be moving before the clicking starts.

4.2.5 If the clicking stops re-boot the computer and call the program, answering N to the prompts for the various setup aids. The volt meter mode may be toggled in and out with the F10 key to provide an idle mode without the clicking or to check the integrity if the various channels.

4.2.6 The system may be shut down at any time without damage to the system; however, the system will have to be re-booted when the system is re-powered.

NOTE

If the processed output appears to contain square waves when starting a run, the program has not synced and must be stopped and started again. This is done by pressing F10 twice.

NOTE

At this point the instrumented wheel sets are properly installed and calibrated. All testing should be completed before tearing down the system as outlined in section 5.0.

5.0 TEST TEAR-DOWN

5.1 Test Equipment Removal and Original Equipment Reinstallation

TASK NUMBER	PROCEDURE	QA INITIAL
5.1.1	Perform calibration operations as outlined in section. Label data as Post Test Calibration.	
5.1.2	Remove all cables from the test vehicle.	
5.1.3	Remove the end plates on the bearing housings.	
5.1.4	Remove the screws holding the connector to the housing.	
5.1.5	Cut all wraps attached to the housing and disconnect the pulse connector on the A wheels.	
5.1.6	Remove the bearing housings.	
5.1.7	Carefully remove the nuts holding the slip ring. Pull the slip ring out far enough to disconnect the cable connector on the rear. After disconnecting the slip ring, push the connector back flush with the end of the bearing.	

5.1.8 Replace all screws.

5.1.9 Store all equipment in a safe place.

5.1.10 Replace the instrumented wheel sets with the original wheel sets by removing the trucks. Be sure to save the machined bearing adaptors. Be sure to install texpads back into original wheel sets.

NOTE

Operations to be performed as in the AAR Car Manual

6.0 QUALITY VERIFICATION

TASK NUMBER	PROCEDURE	QA INITIAL
6.1	Quality verified that PKRG 3300 is complete and closed.	
6.2	Authorized QA signature______________________________.	

305

AXLE 1

SCU CARD	WHEEL	SIGNAL	BRIDGE EXCITATION *	BRIDGE EXCITATION **
1	A	VERT A	11.00 +/- .05	
2	A	VERT B	11.00 +/- .05	
3	A	VERT C	11.00 +/- .05	
4	A	LAT A	11.00 +/- .05	
5	A	LAT B	11.00 +/- .05	
6	B	VERT A	11.00 +/- .05	
7	B	VERT B	11.00 +/- .05	
8	B	VERT C	11.00 +/- .05	
9	B	LAT A	11.00 +/- .05	
10	B	LAT B	11.00 +/- .05	
11	B	TORQUE	11.00 +/- .05	

* AT THE WHEEL
** AT THE AMPLIFIER WITH ACTUAL CABLES

Table 3-1 Excitation Setup Table Blank Table

AXLE 2

SCU CARD	WHEEL	SIGNAL	BRIDGE EXCITATION *	BRIDGE EXCITATION **
1	A	VERT A	11.00 +/- .05	
2	A	VERT B	11.00 +/- .05	
3	A	VERT C	11.00 +/- .05	
4	A	LAT A	11.00 +/- .05	
5	A	LAT B	11.00 +/- .05	
6	B	VERT A	11.00 +/- .05	
7	B	VERT B	11.00 +/- .05	
8	B	VERT C	11.00 +/- .05	
9	B	LAT A	11.00 +/- .05	
10	B	LAT B	11.00 +/- .05	
11	B	TORQUE	11.00 +/- .05	

*** AT THE WHEEL**
**** AT THE AMPLIFIER WITH ACTUAL CABLES**

Table 3-2 Excitation Table Blank Table

307

AXLE 1

SCU CARD	WHEEL	SIGNAL	SHUNT CALIBRATION RESISTOR *	SHUNT CALIBRATION RESISTOR **
1	A	VERT A	2.90	
2	A	VERT B	2.90	
3	A	VERT C	8.23	
4	A	LAT A	3.79	
5	A	LAT B	3.79	
6	B	VERT A	2.86	
7	B	VERT B	2.86	
8	B	VERT C	8.12	
9	B	LAT A	3.86	
10	B	LAT B	3.86	
11		TORQUE	6.21	

*** AT THE WHEEL**
**** AT THE AMPLIFIER WITH ACTUAL CABLES**

Table 3-3 Gain Calibration Blank Table

AXLE 2

SCU CARD	WHEEL	SIGNAL	SHUNT CALIBRATION RESISTOR *	SHUNT CALIBRATION RESISTOR **
1	A	VERT A	2.93	
2	A	VERT B	2.93	
3	A	VERT C	8.32	
4	A	LAT A	3.81	
5	A	LAT B	3.81	
6	B	VERT A	2.96	
7	B	VERT B	2.96	
8	B	VERT C	8.41	
9	B	LAT A	3.79	
10	B	LAT B	3.79	
11		TORQUE	6.20	

* AT THE WHEEL
** AT THE AMPLIFIER WITH ACTUAL CABLES

**TABLE 3-4 GAIN CALIBRATION
BLANK TABLE**

AXLE 1

SCU CARD	WHEEL	SIGNAL	BRIDGE EXCITATION *	BRIDGE EXCITATION **
1	A	VERT A	11.00 +/- .05	11.84
2	A	VERT B	11.00 +/- .05	11.81
3	A	VERT C	11.00 +/- .05	11.39
4	A	LAT A	11.00 +/- .05	11.38
5	A	LAT B	11.00 +/- .05	11.42
6	B	VERT A	11.00 +/- .05	11.75
7	B	VERT B	11.00 +/- .05	11.76
8	B	VERT C	11.00 +/- .05	11.42
9	B	LAT A	11.00 +/- .05	11.39
10	B	LAT B	11.00 +/- .05	11.36
11	B	TORQUE	11.00 +/- .05	11.26

*** AT THE WHEEL**
**** AT THE AMPLIFIER WITH ACTUAL CABLES**

TABLE 4-1 Excitation Setup Tables 250-foot Cables

AXLE 2

SCU CARD	WHEEL	SIGNAL	BRIDGE EXCITATION *	BRIDGE EXCITATION **
1	A	VERT A	11.00 +/- .05	11.69
2	A	VERT B	11.00 +/- .05	11.68
3	A	VERT C	11.00 +/- .05	11.35
4	A	LAT A	11.00 +/- .05	11.32
5	A	LAT B	11.00 +/- .05	11.36
6	B	VERT A	11.00 +/- .05	11.68
7	B	VERT B	11.00 +/- .05	11.68
8	B	VERT C	11.00 +/- .05	11.37
9	B	LAT A	11.00 +/- .05	11.39
10	B	LAT B	11.00 +/- .05	11.37
11	B	TORQUE	11.00 +/- .05	11.25

*** AT THE WHEEL**
**** AT THE AMPLIFIER WITH ACTUAL CABLES**

TABLE 4-2 Excitation Setup Table 250-foot Cables

AXLE 2

SCU CARD	WHEEL	SIGNAL	SHUNT CALIBRATION RESISTOR *	SHUNT CALIBRATION RESISTOR **
1	A	VERT A	2.93	3.38
2	A	VERT B	2.93	3.34
3	A	VERT C	8.32	8.87
4	A	LAT A	3.81	4.09
5	A	LAT B	3.81	4.09
6	B	VERT A	2.96	3.27
7	B	VERT B	2.96	3.24
8	B	VERT C	8.41	8.69
9	B	LAT A	3.79	4.12
10	B	LAT B	3.79	4.13
11		TORQUE	6.20	6.50

*** AT THE WHEEL**
**** AT THE AMPLIFIER WITH ACTUAL CABLES**

Table 4-3 Gain Calibration 250-foot Cables

312

AXLE 2

SCU CARD	WHEEL	SIGNAL	SHUNT CALIBRATION RESISTOR *	SHUNT CALIBRATION RESISTOR **
1	A	VERT A	2.93	3.31
2	A	VERT B	2.93	3.28
3	A	VERT C	8.32	8.85
4	A	LAT A	3.81	4.05
5	A	LAT B	3.81	4.05
6	B	VERT A	2.96	3.35
7	B	VERT B	2.96	3.33
8	B	VERT C	8.41	8.95
9	B	LAT A	3.79	4.03
10	B	LAT B	3.79	4.03
11		TORQUE	6.20	6.47

*** AT THE WHEEL**
**** AT THE AMPLIFIER WITH ACTUAL CABLES**

Table 4-4 Gain Calibration 250-foot Cables

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