

TEST REPORT FOR:

Virginia Department of Transportation
SKT SP 350 50' (15.24 m) System



PREPARED FOR:

Virginia Department of Transportation
1401 E. Broad St.
Richmond, VA 23219

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SECTION 1

INTRODUCTION

1.1 OBJECTIVES

The objective of this crash test was to evaluate the impact performance of the Road Systems, Inc. SKT SP 350 50' (15.24 m) system. This report presents the results of one (1) full-scale crash test conducted on one SKT SP 350 50' (15.24 m) System. For this test, the terminal section was installed on the front end of a 34.3 m (112.5 ft.) length of guardrail.

The test was conducted in accordance with instructions provided by the Virginia Department of Transportation.

1.2 TEST FACILITY

This test was conducted at KARCO Engineering's test facility in Adelanto, California. The tow road is a continuous level surface constructed of reinforced concrete and measures 700 ft. long by 14 ft. wide by 6 in. thick. A steel rail is embedded in the road to provide vehicle guidance. Vehicle tow propulsion is provided by a 1 ton truck using a 1-to-2 pulley system. The test vehicle is towed to within 25 ft. of the barrier by a nylon rope clamped to a 3/8 in. steel cable. The clamp is released from the cable on contact with a cable release mechanism positioned to allow the test vehicle to proceed under its own momentum for a maximum of 25 ft. before impacting the barrier.

1.3 TEST ARTICLE

The Road Systems, Inc. SKT SP 350 50' (15.24 m) System is a standard post guardrail terminal/end treatment. The as-tested SKT SP 350 50' (15.24 m) System consisted of one (1) SKT impact head, two (2) hinged posts, seven (7) standard I-beam line posts, two (2) W-beam rail panels, and one (1) cable anchor assembly. The terminal section was installed with a 50:1 flare and a rail height ranging from 705 mm (27.75 in.) to 730 mm (28.75 in.) per Virginia Department of Transportation (VDOT) Road and Bridge Standards.

Post 1 consisted of one (1) 0.7 m (2.4 ft.) long top post constructed of 6.0" x 6.0" x 0.125" steel tube and one (1) 1.8 m (6.0 ft.) long bottom post constructed of W6 x 15 steel I-beam. The posts were pinned together by a 229 mm (9.0 in.) long 16 mm (0.625 in.) diameter grade 5 hex head bolt, 16 mm (0.625 in.) diameter washers, and a 16 mm (0.625 in.) diameter nut. The bottom portion of post 1 had three (3) 13 mm (0.5 in.) thick plates welded at the top end, one (1) at each flange and one (1) on the upstream side of the post. A 356 mm (1.17 ft.) wide by 508 mm (1.7 ft.) tall by 5 mm (0.19 in.) thick soil plate was attached to the downstream side of the W6 x 15 steel I-beam, 152 mm (6.0 in.) down from the top end.

Post 2 consisted of one (1) 1.1 m (3.5 ft.) long bottom post and one (1) 0.9 m (2.8 ft.) long top post, both pieces were constructed of W6 x 9 steel I-beam. The bottom post had one (1) 178 mm (7.0 in.) long by 102 mm (4.0 in.) wide by 0.375 in. (10 mm) thick plate welded to each flange. The top and bottom post were pinned together by an 18 mm (0.75 in.) diameter by 216 mm (8.5 in.) long ASTM A449 hex head bolt and an 18 mm (0.75 in.) diameter nut.

The cable assembly was attached to post 1 with a 16 mm (0.625 in.) thick, 203 mm (8.0 in.) square steel bearing plate. The bearing plate had a 29 mm (1.125 in.) diameter hole drilled at the center of the plate through which the cable anchor was inserted and fastened with a washer and nut. The opposite end of the assembly was attached to the rail with a quick release cable anchor. The cable anchor attached to the rail with eight (8) 13 mm (0.5 in.) diameter shoulder bolts with washers, eight (8) 13 mm (0.5 in.) structural nuts, and eight (8) 13 mm (0.5 in.) structural washers. The cable anchor was composed of one (1) 6 mm (0.25 in.) thick cable release bracket and one (1) 13 mm (0.5 in.) cable release plate.

The SKT impact head sits on the W-beam rail between post 1 and 2. The head assembly has a total length of 2.1 m (6.9 ft.). The front impacted section of the impact head is 510 mm (20.1 in.) wide by 510 mm (20.1 in.) tall. The rear section of the SKT impact head is composed of a chute that partially encloses the rail. The chute is 185 mm (7.3 in.) wide by 349 mm (13.75 in.) tall at the downstream end. The SKT impact head has a curved deflector plate composed of a 5 mm (0.19 in.) thick plate within the impact head.

Two (2) 7.6 m (25.0 ft.) long rail panels are mounted to the posts of the terminal section with the splices located at post 5. The first rail panel was a 7.6 m (25.0 ft.) panel and composed of 12 Ga. W-beam. The leading edge of the rail had a series of thirteen (13) 0.5" x 4.0" slots. Three (3) 0.75" x 2.5" post slots were located at the center height of the rail. The posts slots were spaced 1.9 m (6.25 ft.) from one another on center. The rail also had eight (8) 19 mm (0.75 in.) diameter holes to attach the cable release bracket to the rail. The second rail was a standard 7.6 m (25.0 ft.) W-beam rail panel. 191mm (7.5 in.) plastic offset blocks were used on post 3 through 9.

For this test, the SKT SP 350 50' (15.24 m) system was adjoined to the end of a 34.3 m (112.5 ft.) length of guardrail, measured from post 9 to post 27. The adjoining guardrail included a 3.8 m (12.5 ft.) long trailing end terminal treatment, measured from post 25 to post 27. The terminal's adjoining barrier consisted of seventeen (17) 1.8 m (6.0 ft.) long W6 x 8.5 standard I-beam line posts, one (1) 8" x 6" wood post with a soil plate and steel foundation tube, four (4) 7.6 m (25.0 ft.) long 12 Ga W-beam rail panels, one (1) 3.8 m (12.5 ft.) long 12 Ga W-beam rail panel, and one (1) cable anchor assembly. 191 mm (7.5 in.) plastic offset blocks were on all posts except the first two (2) posts and last wooden post.

With the exception of post 1, 2 and the trailing end terminal post, the post were installed by drilling 0.3 m (1.0 ft.) diameter by 0.3 m (1.0 ft.) deep pilot holes and driving the posts into the soil. The first two posts as well as the trailing end terminal post were installed by drilling a 0.6 m (2.0 ft.) diameter hole. Post 1 and the trailing end terminal post were drilled to a depth of 1.8 m (6.0 ft.) while post 2 was drilled to a depth of 1.2 m (4.0 ft.). The holes were backfilled and compacted with a pneumatic compactor.

Photographs of the as-tested unit and installation are available in Appendix A of this report. Manufacturer's drawings are available in Appendix D. The installation instructions are included on KARCO CD-R 2016-4055.

SECTION 2

TEST PROCEDURE AND INSTRUMENTATION SUMMARY

2.1 TEST PROCEDURE

To meet the recommended properties of the NCHRP 350 test vehicle requirements, a commercially available production model test vehicle was selected. The test vehicle was free of major body damage and was not missing any structural components. The bumpers were standard equipment and were not modified for this test. All fluids were drained and the battery was removed.

The NCHRP 350 recommended test vehicle properties are shown in Table 1. The 820C test vehicle was used for this test. The 820C test vehicle used for this test was a front engine model with front wheel drive and an automatic transmission.

Table 1. Recommended Properties of 700C, 820C and 2000P Test Vehicles

PROPERTY	700C (Small Car)	820C (Small Car)	2000P (Pickup Truck)
MASS (kg)			
Test Inertial Dummy	700 ± 25	820 ± 25	2000 ± 45
Maximum Ballast Gross Static	75 70 775 ± 25	75 80 895 ± 25	--- 200 2000 ± 45
DIMENSIONS (cm)			
Wheelbase	230 ± 10	230 ± 10	335 ± 25
Front Overhang	75 ± 10	75 ± 10	80 ± 10
Overall Length	370 ± 20	370 ± 20	535 ± 25
Track Width (average)	135 ± 10	135 ± 10	165 ± 15
CENTER OF MASS LOCATION (cm)			
Aft of Front Axle Above Ground	80 ± 15 55 ± 5	80 ± 15 55 ± 5	140 ± 15 70 ± 5
LOCATION OF ENGINE	Front	Front	Front
LOCATION OF DRIVE AXLE	Front	Front	Rear
TYPE OF TRANSMISSION	Manual or Automatic	Manual or Automatic	Manual or Automatic

2.2 CRASH TEST SET UP

A full-scale crash test was conducted to evaluate the impact performance of the SKT SP 350 50' (15.24 m) System. The test conditions were as follows: A 820 kg (1808 lb.) small car approaching the test article at a nominal speed of 100 km/h (62 mph) with a critical impact angle of 5°. The test article was installed so that the vehicle centerline intersected the leading edge of the W-beam rail.

2.3 TEST INSTRUMENTATION AND DATA ACQUISITION PROCEDURES

All data acquisition for this certification test was performed in accordance with the NCHRP 350 Recommended Procedure requirements.

2.3.1 Test Vehicle Instrumentation: The test vehicle was instrumented with one (1) tri-axial accelerometer and one tri-axial angular rate sensor. Both the accelerometer and the angular rate sensor were installed within a 5 cm radial of the vehicle's longitudinal and lateral center of gravity. The accelerometers measured longitudinal (x), lateral (y) and vertical (z) acceleration. The angular rate sensors measured vehicle roll, pitch and yaw. Data was recorded using the on-board TDAS. Data was linked to a personal computer and processed using the TDAS Control software. All equipment used in this test meets the requirements of SAE J211.

2.3.1.2 Calibration: All instrumentation used in this test has been calibrated through standards traceable to NIST and is maintained in a calibrated condition.

2.3.2 TDAS Software: The software utilized in this system is written in National Instruments Lab Windows/CVI (C, Visual Interface) programming language, which is a Windows based software package with emphasis on ease of use and good engineering test practices.

2.3.3 SAE Compatibility: The software contains standard point and click processing options for selecting Society of Automotive Engineers (SAE) class post filters and calculating the required integrals, resultants, Head Injury Criteria (HIC), clips, and other data processing parameters that may be required.

2.3.4 Measurement Uncertainty: Measurement uncertainties have been determined for pertinent values affecting the results of this test. KARCO maintains these uncertainty budgets, which are available upon request, but are not included in this report. In certain cases the nature of the test method may preclude rigorous and statistically valid calculation of uncertainty of measurement. In these cases KARCO attempts to identify the components of uncertainty and make a reasonable estimation. Reasonable estimation is based on knowledge of the performance of the method and on the measurement scope and makes use of, for example, previous experience and validation data.

2.3.5 Photographic Documentation: Photographic documentation of this test included a minimum of two (2) real-time video camera at 30 frames per second (fps), and four (4) high-speed color digital video cameras at 1000 fps All high-speed cameras were activated by a pressure-sensitive tape switch, which was positioned on the test article to indicate the instant of contact (time zero). A digital still camera was used for documenting the pre- and post-test condition of the test vehicle and the SKT SP 350 50' (15.24 m) System.

2.3.6 Anthropomorphic Test Device: An uninstrumented Hybrid III 50th percentile adult male Anthropomorphic Test Device was placed in the driver seat of the test vehicle.

SECTION 3 TEST RESULTS

This 100 km/h (62 mph) impact crash test was conducted using a 1999 Chevrolet Metro small car to evaluate the impact performance of the SKT SP 350 50' (15.24 m) System. The test article was installed at an angle of 5° relative to the test vehicle's direction of travel, with the vehicle's centerline intersecting the leading edge of the W-beam rail. This crash test was documented by two (2) real-time and six (6) high-speed video cameras. Pre- and post-test photographs of the test vehicle and test article can be found in Appendix A.

The test was conducted on June 30, 2016. The as-tested test inertial weight of the vehicle was 832.0 kg (1,834.2 lbs.). The height of the front bumper was 212 mm (8.3 in.) to the lower edge and 545 mm (21.5 in.) to the upper edge. Additional dimensions and test vehicle information are presented in Data Sheets No. 1 and 2.

The test vehicle impacted the SKT SP 350 50' (15.24 m) System at a velocity of 99.75 km/h (61.98 mph). The test vehicle impacted the SKT impact head and pushed it down the guardrail past the first four posts. Approximately mid-span between post four and five, the rail kinked at the chute of the SKT impact head. As the vehicle moved forward the rail kinked a second time at post 5 and the SKT impact head impacted the left door of the test vehicle. The test vehicle came to rest approximately 31.2 m (102.4 ft.) downstream and 1.9 m (6.2 ft.) towards the non-traffic side of its position at the point of impact. As a result of the impact, post one broke away, post 2 folded to the ground and line post 3 and 4 bent towards the ground. The rail separated from post 2 through 5 and bent around post 5. The SKT impact head had a tear at the end of its chute. An overhead illustration of the test vehicle and test article in their pre-test and post-test conditions is shown in Figure 2 in Appendix D. Sequential photographs of the test sequence are shown on Data Sheet 4.

The vehicle sustained damage to the front end. The front bumper and hood were subject to damage as a result of the impact with the SKT SP 350 50' (15.24 m) system. The front bumper fascia and bumper beam both detached from the vehicle during the impact. The left front door sustained damage from the impact with the SKT impact head. The occupant compartment was not penetrated as a result of the impact.

A summary of the electronic data is presented in Data Sheet No. 6; data plots are presented in Appendix B.

SECTION 4
DATA SHEETS

Test Article: SKT SP 350 50' (15.24 m) System Project No. P36130-01
 Test Program: 100 km/h 5° Guardrail Terminal Impact Test Test Date: 06/30/16

CONVERSION FACTORS

Quantity	Typical Application	Std Units	Metric Unit	Multiply By
Mass	Vehicle Weight	lb	kg	0.4536
Linear Velocity	Impact Velocity	miles/hr	km/hr	1.609344
Length or Distance	Measurements	in	mm	25.4
Volume	Fuel Systems	gal	liter	3.785
Volume	Small Fluids	oz	mL	29.574
Pressure	Tire Pressures	lbf/in ²	kPa	6.895
Temperature	General Use	°F	°C	$=(T_f - 32)/1.8$
Force	Dynamic Forces	lbf	N	4.448
Moment	Torque	lbf-ft	N•m	1.355

DATA SHEET 1

TEST VEHICLE INFORMATION

Test Article: SKT SP 350 50' (15.24 m) System Project No. P36130-01
 Test Program: 100 km/h 5° Guardrail Terminal Impact Test Test Date: 06/30/16

TEST VEHICLE INFORMATION

Make	Chevrolet	Cylinders	Inline 4
Model	Metro	Engine Displacement (L)	1.3
Body Style	3-Door Hatchback	Engine Placement	Transverse
VIN	2C1MR222XX6722334	Fuel Type	Gasoline
Color	Red	Transmission	Automatic
Odometer Reading (mi)	185,262	Final Drive	Front
Previous Damage to Vehicle		Minor dents and scratches	

DATA FROM CERTIFICATION LABEL

Manufactured By	Cami Automotive Inc. Canada	GVWR (kg)	1190
		GAWR Front (kg)	650
Date of Manufacture	Apr-99	GAWR Rear (kg)	560

TEST VEHICLE WEIGHTS

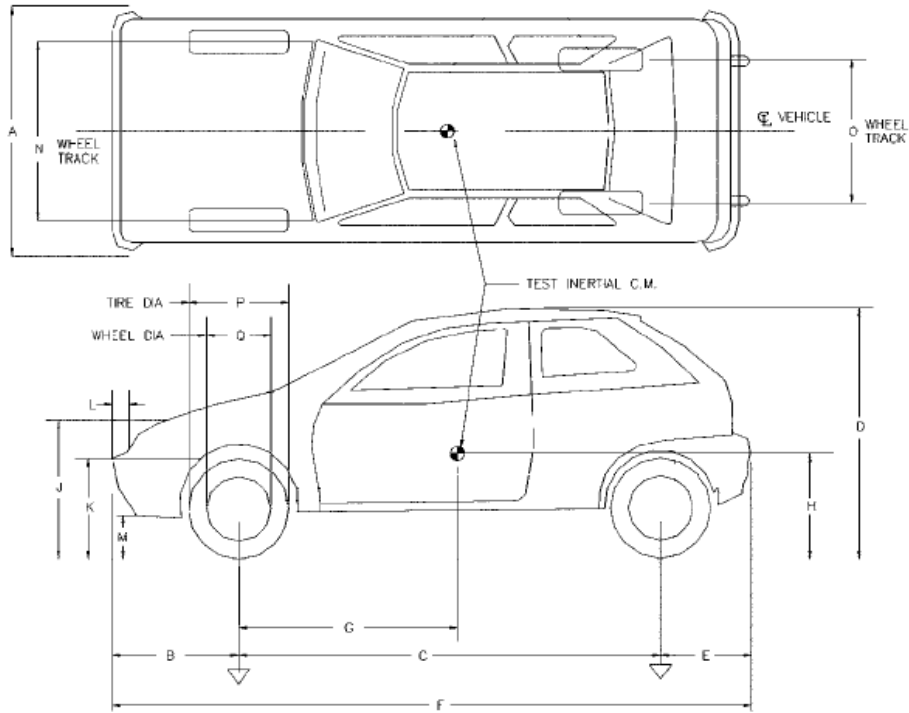
	As Received (kg)			Test Inertial (kg)			Gross Static (kg)		
	Front	Rear	Total	Front	Rear	Total	Front	Rear	Total
Left	283.0	147.0	430.0	266.5	144.0	410.5	292.5	171.0	463.5
Right	272.0	155.5	427.5	264.0	157.5	421.5	270.5	174.0	444.5
Ratio (%)	64.7	35.3	100.0	63.8	36.2	100.0	62.0	38.0	100.0
Total	555.0	302.5	857.5	530.5	301.5	832.0	563.0	345.0	908.0

	As Received (lb)			Test Inertial (lb)			Gross Static (lb)		
	Front	Rear	Total	Front	Rear	Total	Front	Rear	Total
Left	623.9	324.1	948.0	587.5	317.5	905.0	644.8	377.0	1021.8
Right	599.6	342.8	942.4	582.0	347.2	929.2	596.3	383.6	979.9
Ratio (%)	64.7	35.3	100.0	63.8	36.2	100.0	62.0	38.0	100.0
Total	1223.5	666.9	1890.4	1169.5	664.7	1834.2	1241.1	760.6	2001.7

DATA SHEET 2

TEST VEHICLE GEOMETRY

Test Article: SKT SP 350 50' (15.24 m) System Project No. P36130-01
 Test Program: 100 km/h 5° Guardrail Terminal Impact Test Test Date: 06/30/16



TEST VEHICLE GEOMETRY

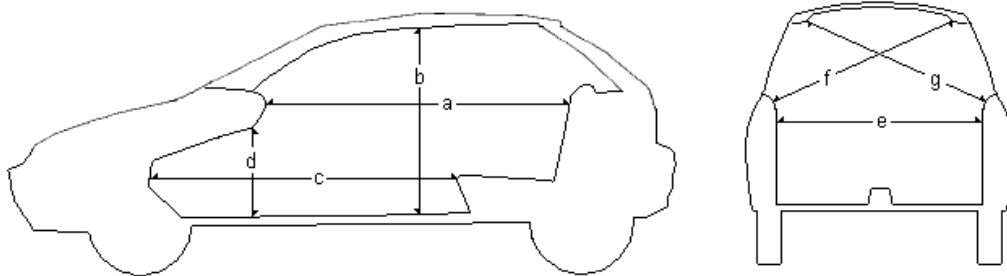
	mm	in.		mm	in.		mm	in.		mm	in.
A	1575	62.0	E	610	24.0	J	612	24.1	N	1400	55.1
B	822	32.4	F	3797	149.5	K	545	21.5	O	1360	53.5
C	2365	93.1	G	857	33.7	L	102	4.0	P	550	21.7
D	1365	53.7	H	541	21.3	M	212	8.3	Q	365	14.4

DATA SHEET 3

OCCUPANT COMPARTMENT DEFORMATION INDEX

Test Article: SKT SP 350 50' (15.24 m) System Project No. P36130-01
 Test Program: 100 km/h 5° Guardrail Terminal Impact Test Test Date: 06/30/16

The seven subindices a, b, c, d, e, f and g indicate the percentage of reduction of seven interior dimensions shown on the following figure:



where,

- a = distance between the dashboard and a reference point at the rear of the occupant compartment, such as top of rear seat, or the rear part of the cab on a pickup;
- b = distance between the roof and the floor panel;
- c = distance between a reference point at the rear of the occupant compartment and the motor panel;
- d = distance between the lower dashboard and the floor panel;
- e = interior width;
- f = distance between the lower edge of right window and the upper edge of left window; and
- g = distance between the lower edge of left window and the upper edge of right window

Sub-Indices	Pre-Test		Post-Test		Percent Reduction
	mm	in.	mm	in.	
A	1526	60.1	1546	60.9	-1.31%
B	1093	43.0	1154	45.4	-5.58%
C	1466	57.7	1427	56.2	2.66%
D	318	12.5	316	12.4	0.63%
E	1256	49.4	1259	49.6	-0.24%
F	1173	46.2	1174	46.2	-0.09%
G	1174	46.2	1178	46.4	-0.34%
Max Deformation	1466	57.7	1427	56.2	2.66%
OCDI	FS0000000				
Comments:	None				

DATA SHEET 4
SUMMARY OF RESULTS

Test Article: SKT SP 350 50' (15.24 m) System

Project No.: P36130-01

Test Program: 100 km/h 5° Guardrail Terminal Impact Test

Test Date: 06/30/16



0 ms



200 ms



400 ms



600 ms



800 ms



1000 ms

GENERAL INFORMATION		OCCUPANT RISK VALUES	
TEST AGENCY	KARCO Engineering, LLC.	FLAIL SPACE VELOCITY (m/s)	
TEST ARTICLE		X DIRECTION	7.4
TYPE	Terminal	Y DIRECTION	0.1
TERMINAL LENGTH ¹	15.3 m (50.2 ft.)	THIV (Optional) (m/s)	7.4
ADJOINING BARRIER LENGTH ²	34.3 m (112.5 ft.)	RIDEDOWN ACCELERATION (g)	
TEST VEHICLE		X DIRECTION	-8.7
TYPE	Production Model	Y DIRECTION	3.7
DESIGNATION	820C	PHD (Optional) (g)	8.7
MODEL	Chevrolet Metro	ASI (Optional)	0.7
MASS (CURB)	857.5 kg (1,890.4 lbs)	VEHICLE DAMAGE	
MASS (TEST INERTIAL)	832.0 kg (1,834.2 lbs)	INTERIOR	
DUMMY MASS	76.0 kg (167.5 lbs)	OCDI	FS0000000
MASS (GROSS STATIC)	908.0 kg (2,001.7 lbs)	POST-IMPACT VEHICULAR BEHAVIOR	
IMPACT CONDITIONS		MAXIMUM ROLL ANGLE (°)	8.6
VELOCITY (km/h)	99.75 km/h (61.98 mph)	MAXIMUM PITCH ANGLE (°)	-7.3
ANGLE (°)	5.3	MAXIMUM YAW ANGLE (°)	25.9
IMPACT SEVERITY (kJ)	319.4		

¹ Terminal Length measured from Post 1 to Post 9

² Adjoining Barrier Length measured from Post 9 to Post 27

DATA SHEET 5
IMPACT CONDITIONS

Test Article: SKT SP 350 50' (15.24 m) System Project No. P36130-01
Test Program: 100 km/h 5° Guardrail Terminal Impact Test Test Date: 06/30/16

Item	Value
Test Time	10:34 AM
Temperature (°C)	35.0 *
Wind Velocity (km/h)	16.1 *
Wind Direction	S *
Impact Speed (km/h)	99.75

*Information provided for reference only

DATA SHEET 6

TEST DATA SUMMARY

Test Article: SKT SP 350 50' (15.24 m) System Project No. P36130-01
Test Program: 100 km/h 5° Guardrail Terminal Impact Test Test Date: 6/30/16

TEST VEHICLE DATA SUMMARY

Tested Parameter	Axis	Units	Max	Time (ms)	Min	Time (ms)
Vehicle Impact Velocity	X	m/s	27.7			
Flail Space Velocity	X	m/s	7.4	146.7		
Flail Space Velocity	Y	m/s	0.1	146.7		
Ridedown Acceleration	X	g	2.1	486.5	-8.7	207.3
Ridedown Acceleration	Y	g	3.7	312.4	-2.7	151.7

TEST VEHICLE ACCELEROMETER PEAK DATA

Location	Axis	Units	Max	Time (ms)	Min	Time (ms)
Vehicle CG	X	g	5.3	444.4	-16.7	26.8
Vehicle CG	Y	g	5.6	155.2	-6.0	144.9
Vehicle CG	Z	g	14.8	452.7	-16.7	446.8

**APPENDIX A
PHOTOGRAPHS**

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FIGURE 1. Test Article, As Received



FIGURE 2. Test Article, As Received



FIGURE 3. Test Vehicle, As Received



FIGURE 4. Test Vehicle, As Received



FIGURE 5. Test Setup



FIGURE 6. Test Setup Close-Up



FIGURE 7. Test Setup



FIGURE 8. Test Setup Close-Up



FIGURE 9. Test Setup



FIGURE 10. Test Setup Close-Up



FIGURE 11. Test Setup



FIGURE 12. Test Setup Close-Up



FIGURE 13. Test Setup



FIGURE 14. Test Setup Close-Up



FIGURE 15. Pre-Test



FIGURE 16. Post-Test



FIGURE 17. Post-Test



FIGURE 18. Post-Test



FIGURE 19. Pre-Test Front View of Test Article



FIGURE 20. Post-Test Front View of Test Article



FIGURE 21. Pre-Test Right Front $\frac{3}{4}$ View of Test Article



FIGURE 22. Post-Test Right Front $\frac{3}{4}$ View of Test Article



FIGURE 23. Pre-Test Right View of Test Article



FIGURE 24. Post-Test Right View of Test Article



FIGURE 25. Pre-Test Right Rear $\frac{3}{4}$ View of Test Article



FIGURE 26. Post-Test Right Rear $\frac{3}{4}$ View of Test Article



FIGURE 27. Pre-Test Rear View of Test Article



FIGURE 28. Post-Test Rear View of Test Article



FIGURE 29. Pre-Test Left Rear $\frac{3}{4}$ View of Test Article



FIGURE 30. Post-Test Left Rear $\frac{3}{4}$ View of Test Article



FIGURE 31. Pre-Test Left View of Test Article



FIGURE 32. Post-Test Left View of Test Article



FIGURE 33. Pre-Test Left Front $\frac{3}{4}$ View of Test Article



FIGURE 34. Post-Test Left Front $\frac{3}{4}$ View of Test Article



FIGURE 35. Test Article Damage



FIGURE 36. Test Article Damage



FIGURE 37. Test Article Damage



FIGURE 38. Test Article Damage



FIGURE 39. Test Article Damage



FIGURE 40. Test Article Damage



FIGURE 41. Pre-Test Left View of Test Vehicle



FIGURE 42. Post-Test Left View of Test Vehicle



FIGURE 43. Pre-Test Left Front $\frac{3}{4}$ View of Test Vehicle



FIGURE 44. Post-Test Left Front $\frac{3}{4}$ View of Test Vehicle



FIGURE 45. Pre-Test Front View of Test Vehicle



FIGURE 46. Post-Test Front View of Test Vehicle



FIGURE 47. Pre-Test Right Front $\frac{3}{4}$ View of Test Vehicle



FIGURE 48. Post-Test Right Front $\frac{3}{4}$ View of Test Vehicle



FIGURE 49. Pre-Test Right View of Test Vehicle



FIGURE 50. Post-Test Right View of Test Vehicle



FIGURE 51. Pre-Test Windshield



FIGURE 52. Post-Test Windshield



FIGURE 53. Pre-Test Driver Side Occupant Compartment



FIGURE 54. Post-Test Driver Side Occupant Compartment



FIGURE 55. Post-Test Driver Side Floorpan



FIGURE 56. Post-Test Driver Side Floorpan



FIGURE 57. Pre-Test Passenger Side Occupant Compartment



FIGURE 58. Post-Test Passenger Side Occupant Compartment



FIGURE 59. Pre-Test Passenger Side Floorpan



FIGURE 60. Post-Test Passenger Side Floorpan

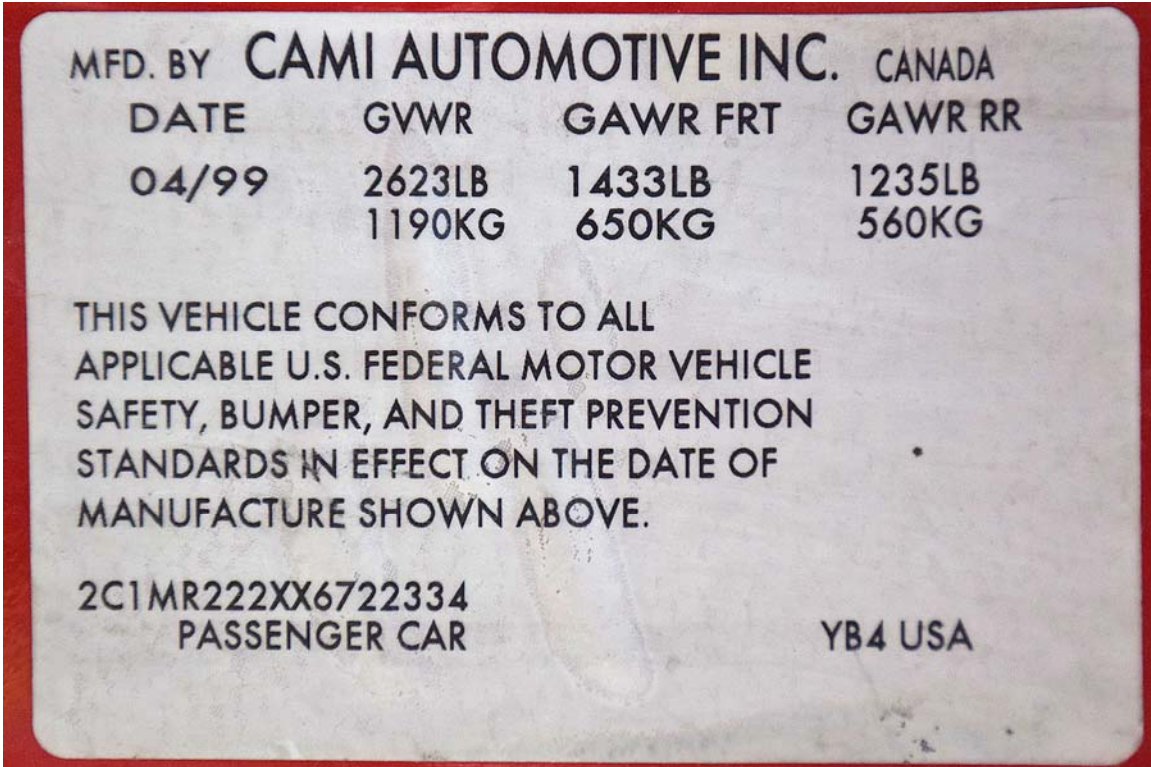


FIGURE 61. Test Vehicle Manufacturer's Label



FIGURE 62. Test Vehicle Tire Information Placard

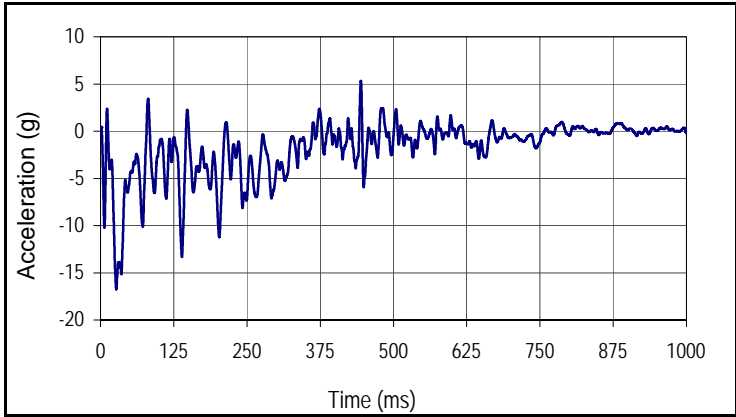
**APPENDIX B
DATA PLOTS**

LIST OF DATA PLOTS

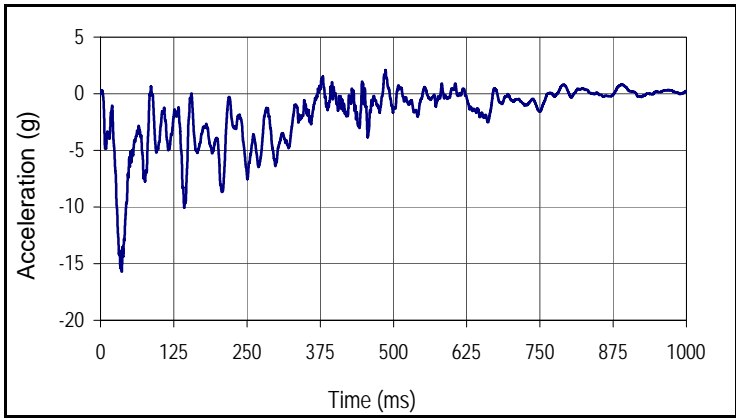
<u>Plot</u>		<u>Page</u>
1	Test Vehicle CG X	B-1
2	Test Vehicle CG X Moving Average	B-1
3	Test Vehicle CG X Velocity	B-1
4	Test Vehicle CG X Displacement	B-1
5	Test Vehicle CG Y	B-2
6	Test Vehicle CG Y Moving Average	B-2
7	Test Vehicle CG Y Velocity	B-2
8	Test Vehicle CG Y Displacement	B-2
9	Test Vehicle CG Z	B-3
10	Test Vehicle Accident Severity Index	B-3
11	Test Vehicle Roll Angle	B-4
12	Test Vehicle Yaw Angle	B-4
13	Test Vehicle Pitch Angle	B-4

Test Article: SKT SP 350 50' (15.24 m) System
 Test Program: 100 km/h 5° Guardrail Terminal Impact Test

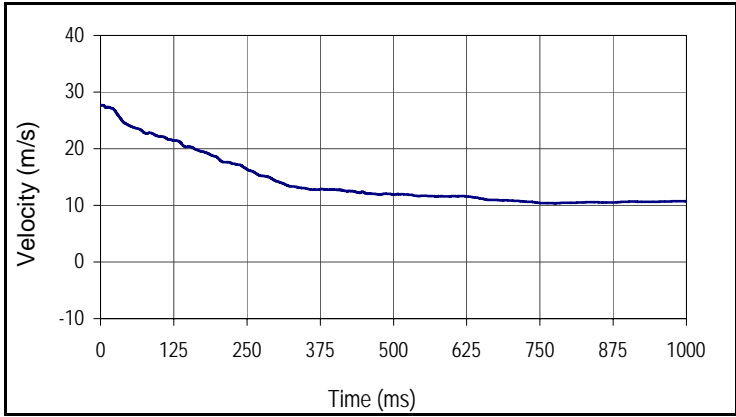
Project No: P36130-01
 Test Date.: 6/30/16



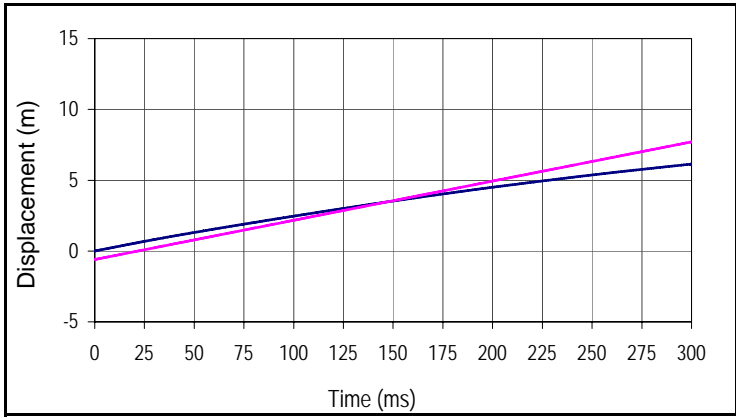
Curve Description			
Test Vehicle CG X			
Plot No.	Type	SAE Class	Units
001	FIL	60	g
Max	Time	Min	Time
5.3	444.4	-16.7	26.8



Curve Description			
Test Vehicle CG X Moving Average			
Plot No.	Type	SAE Class	Units
002	AVG	180	g
Max	Time	Min	Time
2.1	486.5	-15.7	36.4



Curve Description			
Test Vehicle CG X Velocity			
Plot No.	Type	SAE Class	Units
003	IN1	180	m/sec
Max	Time	Min	Time
27.7	3.2	10.4	775.2

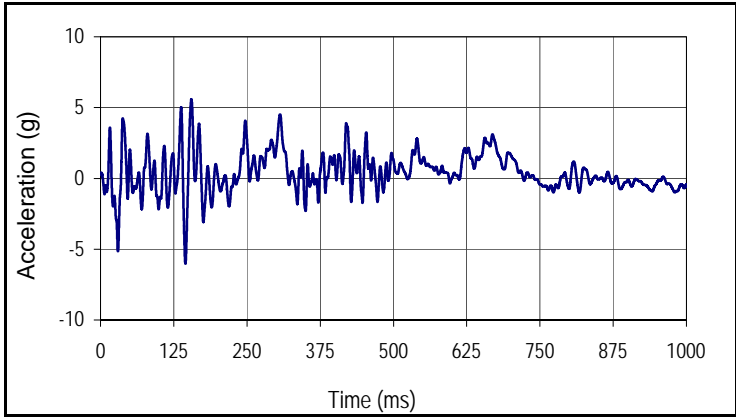


Curve Description			
Test Vehicle CG X Displacement			
Plot No.	Type	SAE Class	Units
004	IN2	180	Meters
Max	Time	Min	Time
25.0	1999.9	0.0	0.0

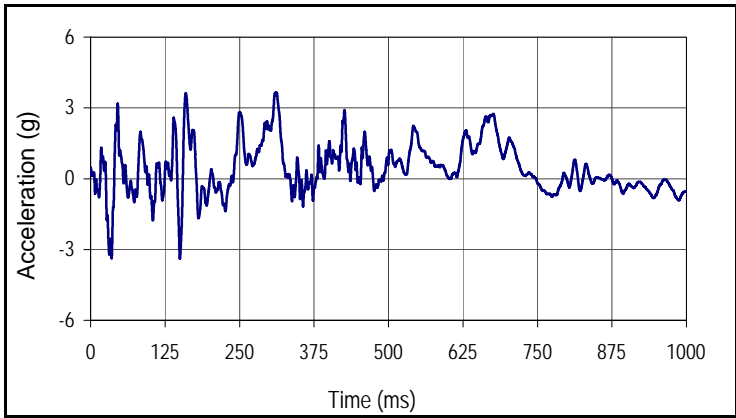
— Vehicle CG X Displacement
 — Occupant X Displacement

Test Article: SKT SP 350 50' (15.24 m) System
 Test Program: 100 km/h 5° Guardrail Terminal Impact Test

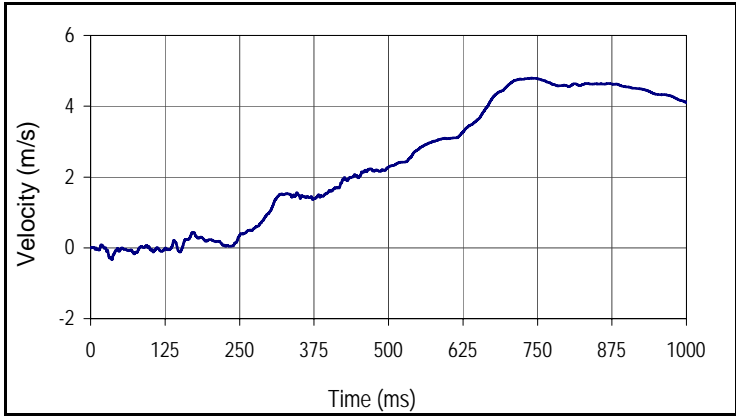
Project No: P36130-01
 Test Date.: 6/30/16



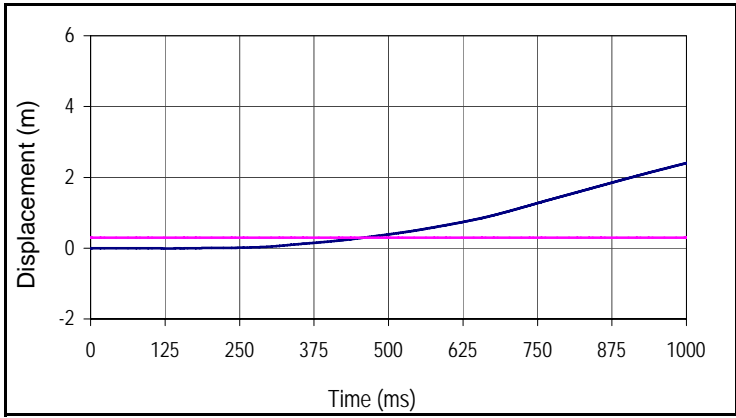
Curve Description			
Test Vehicle CG Y			
Plot No.	Type	SAE Class	Units
005	FIL	60	g
Max	Time	Min	Time
5.6	155.2	-6.0	144.9



Curve Description			
Test Vehicle CG Y Moving Average			
Plot No.	Type	SAE Class	Units
006	AVG	180	g
Max	Time	Min	Time
3.7	312.4	-3.4	149.9



Curve Description			
Test Vehicle CG Y Velocity			
Plot No.	Type	SAE Class	Units
007	IN1	180	m/sec
Max	Time	Min	Time
4.8	740.0	-0.3	35.8

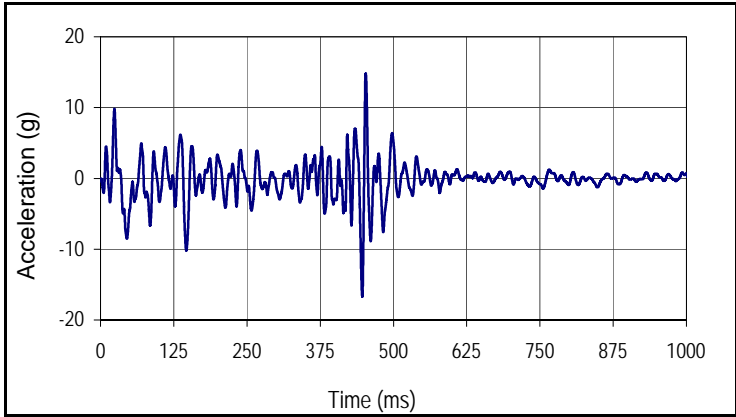


Curve Description			
Test Vehicle CG Y Displacement			
Plot No.	Type	SAE Class	Units
008	IN2	180	Meters
Max	Time	Min	Time
4.2	1999.9	0.0	135.4

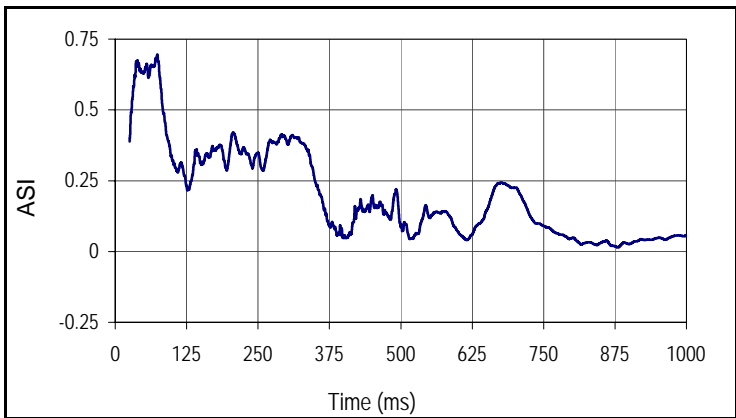
— Vehicle CG Y Displacement
 — Occupant Y Displacement

Test Article: SKT SP 350 50' (15.24 m) System
 Test Program: 100 km/h 5° Guardrail Terminal Impact Test

Project No: P36130-01
 Test Date.: 6/30/16



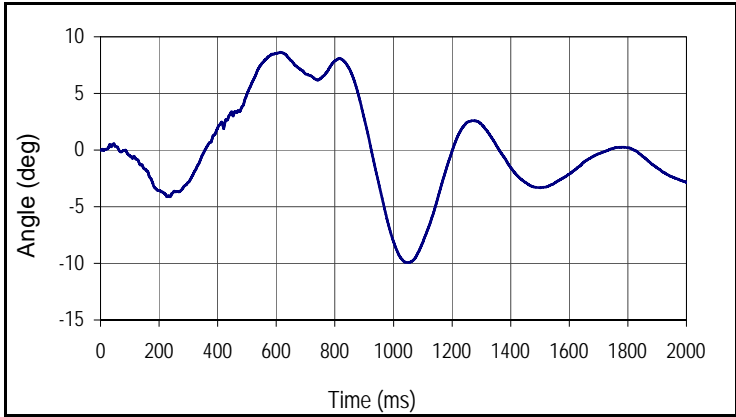
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Test Vehicle CG Z			
Plot No.	Type	SAE Class	Units
009	FIL	60	g
Max	Time	Min	Time
14.8	452.7	-16.7	446.8



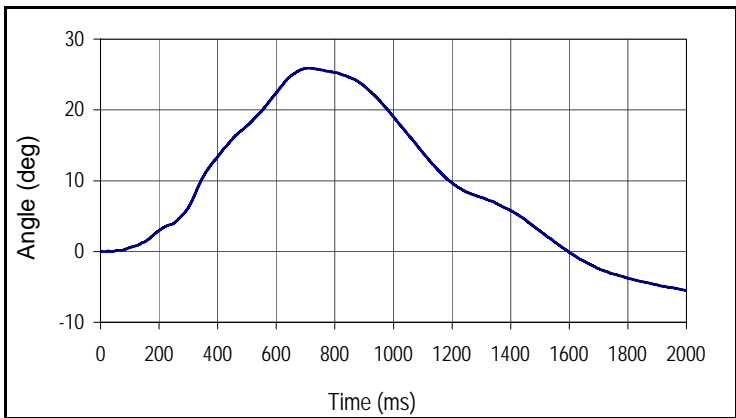
Curve Description			
Test Vehicle Accident Severity Index			
Plot No.	Type	SAE Class	Units
010	ASI	180	ASI
Max	Time	Min	Time
0.7	73.6	0.0	879.3

Test Article: SKT SP 350 50' (15.24 m) System
 Test Program: 100 km/h 5° Guardrail Terminal Impact Test

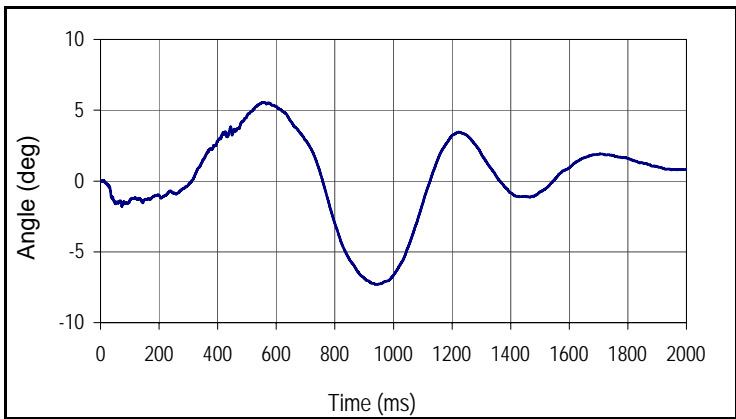
Project No: P36130-01
 Test Date.: 6/30/16



Curve Description			
Test Vehicle Roll Angle			
Plot No.	Type	SAE Class	Units
011	IN1	180	Degrees
Max	Time	Min	Time
8.6	614.2	-9.9	1052.8



Curve Description			
Test Vehicle Yaw Angle			
Plot No.	Type	SAE Class	Units
012	IN1	180	Degrees
Max	Time	Min	Time
25.9	719.2	-5.5	1999.9



Curve Description			
Test Vehicle Pitch Angle			
Plot No.	Type	SAE Class	Units
013	IN1	180	Degrees
Max	Time	Min	Time
5.5	558.2	-7.3	943.3

**APPENDIX C
INSTRUMENTATION**

DATA ACQUISITION INFORMATION

Test Article: SKT SP 350 50' (15.24 m) System Project No. P36130-01
Test Program: 100 km/h 5° Guardrail Terminal Impact Test Test Date: 06/30/16

VEHICLE INSTRUMENTATION

CH	Location	Axis	Ident. No.	Description	MFR	Model	Units
1	Vehicle CG	X	P51708	Accel, Half Bridge	Endevco	2000G	g
2	Vehicle CG	Y	P51700	Accel, Half Bridge	Endevco	2000G	g
3	Vehicle CG	Z	P51696	Accel, Half Bridge	Endevco	2000G	g
4	Vehicle CG	Yaw	ARS8486	Rate Gyro	DTS	ARS-18K	Deg/s
5	Vehicle CG	Pitch	ARS8532	Rate Gyro	DTS	ARS-18K	Deg/s
6	Vehicle CG	Roll	ARS8537	Rate Gyro	DTS	ARS-18K	Deg/s

APPENDIX D
MANUFACTURER DOCUMENTS

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Manufacturer's Drawing	D-1
2	Overhead Illustration	D-2

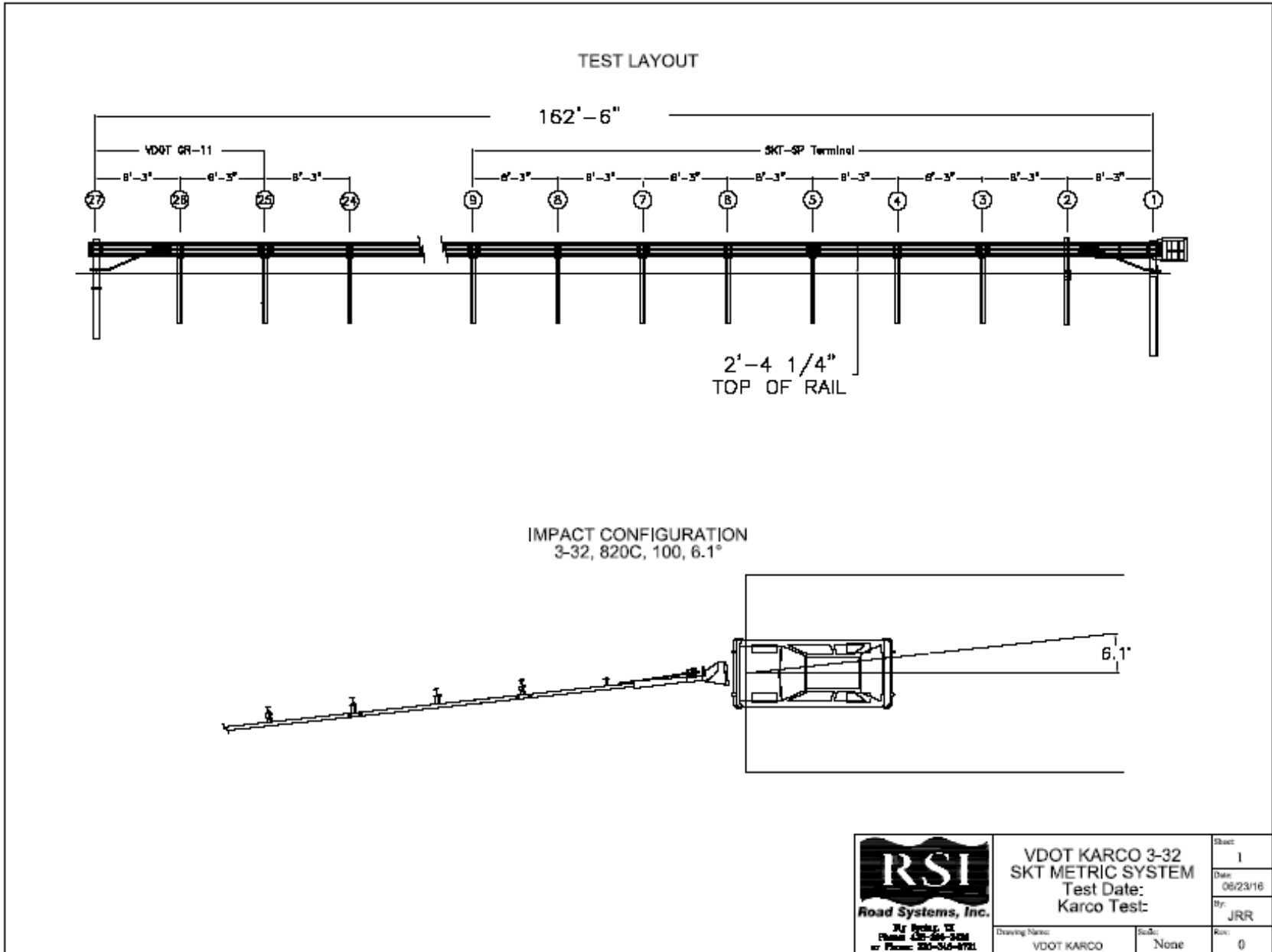


FIGURE 1. Manufacturer's Drawing

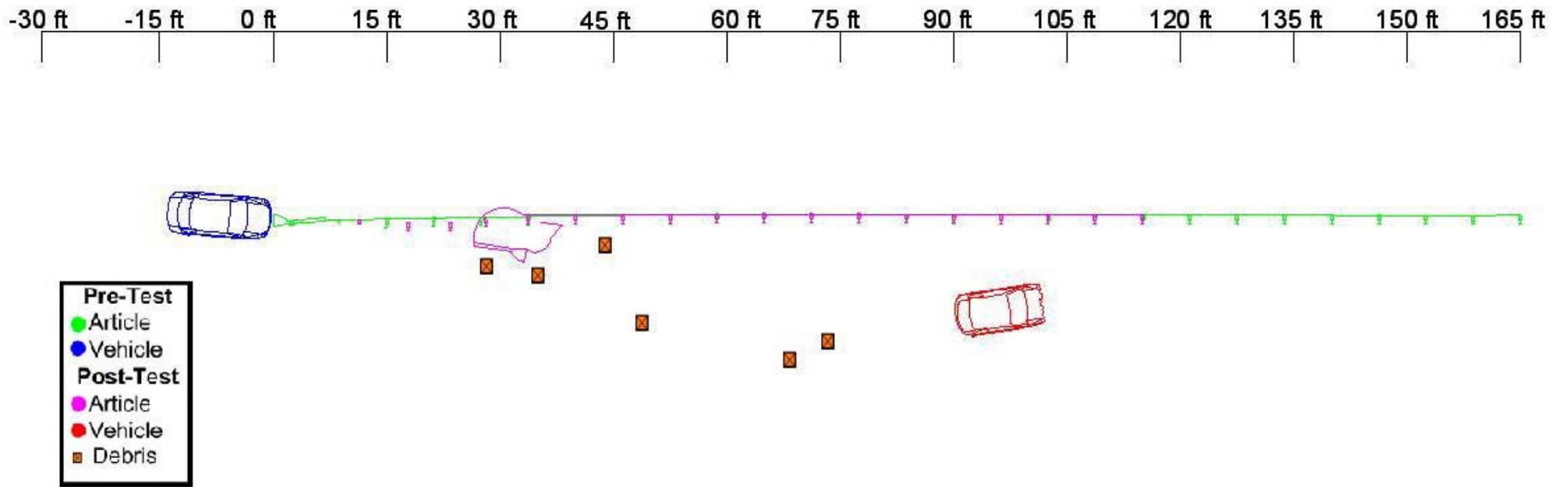


FIGURE 2. Overhead Illustration
FINAL PAGE OF REPORT